

Axiotron 2

CSM VIS-UV

Operator Manual



Knowledge of this manual is required to operate the Axiotron 2. Please familiarize yourself with the contents of this manual and pay close attention to instructions concerning the safe operation of this instrument.

The specifications herein are subject to change. This manual, especially the printed hard copy, is not covered by an update service.

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2 GENERAL INFORMATION

2.1 Legal Matters

2.1.1 Definition of Symbols Used in This Handbook

The following generic warning and information symbols are used in this manual. Additionally, specific warning symbols are used in conjunction with a plain-text explanation of the possible hazards involved. As most of them are only used once, they are not specifically referred to in this section.

The following generic symbols are used frequently throughout the manual and are explained in detail for that reason:

**NOTE**

This symbol indicates additional information for the user.

**DANGER**

This symbol is a warning that indicates an immediate danger, which causes a potential risk for injury or death to the user.

**CAUTION**

This symbol is a warning that indicates a hazard to the tool.

2.1.2 CE Compliance Statement

CERTIFICATE OF CONFORMITY



The manufacturer,
Der Hersteller,

HSEB Dresden GmbH
Manfred-von-Ardenne-Ring 4
01099 Dresden
Germany

declares in it's sole responsibility, that the product
erklärt in alleiniger Verantwortung, daß das Produkt

Axiotron 2 / Axiotron 2 CSM VIS-UV

Inspection Microscope
Inspektionsmikroskop

and all it's declared components included in delivery, meet the requirements
of the following harmonized directives

und alle zum Lieferumfang deklarierten Zubehörteile, auf welche sich diese Erklärung bezieht,
den folgenden harmonisierten Normen entspricht:

- 89/392/EEC (Machine Directive)
- 72/23/EEC (Low Voltage Directive)
- 89/336/EEC (Electromagnetic Compatibility Directive)

Applied harmonized standards:

Angewandte harmonisierte Normen:

- | | |
|------------------|------------------|
| • DIN EN 1050 | • DIN EN 61010-1 |
| • DIN EN 60204-1 | • DIN EN 60825-1 |
| • DIN EN 61326 | |

Dresden, 2005-05-03

Manfred Heinze
Managing Director
Geschäftsführer

figure 1 CE compliance statement for Axiotron 2

2.1.3 Safety Precautions

Particular attention must be paid to the following warning notes.



THIRD PARTY MANUALS AND SAFETY NOTES

All third party manuals, notes and other printed or electronic documentation, which has been delivered together with the tool, are part of the system's documentation and needs to be read carefully, before the system is put into operation for the first time. The existence of this Operator Manual does not replace the necessity to read said third party material, especially with regard to Safety measures.



TRAINED PERSONNEL REQUIRED

The tool may only be installed and operated by trained personnel, who are aware of the possible issues that are involved with the use of it. It is a mechanical and optical precision system that can be impaired in its performance or damaged if handled improperly.



LIABILITY

The manufacturer cannot assume liability for

... any application not specified herein, possibly also involving individual modules or single parts. This also applies to all service or repair work which is not carried out by authorized service personnel or spare parts obtained from non-authorized sources. In this case, all claims against warranty will be forfeited.

... any damage of property, harm or injury that is caused by a use of the tool in a manner not specified, or by users failing to observe the provisions and/or cautions given in this manual, thus exposing them to risks or hazards that could have been avoided otherwise.



LASER LIGHT

Certain configurations of the microscope are equipped with a Class 3A laser diode with a wavelength of 785 nm and a continuous-wave emitted power of 5 mW. This laser diode is located inside the microscope. Access to this module is only possible after the removal of microscope parts by means of special tools. Under normal operating conditions the autofocus is categorized as a Class I device as per DIN EN 60825 and it is safe to operate it. Improper use of the tool, as well as unauthorized disassembly of the Axiotron 2 microscope may expose the laser diode's beam path and render the system in a Class 3 condition. Therefore it is strictly prohibited to open any of its covers, while the system is powered on. Warning labels indicate the presence of laser devices.

**HANDLING OF HAZARDOUS SUBSTANCES**

The tool is not equipped with any special devices for protection from substances which are corrosive, toxic, radioactive or otherwise hazardous to health. All legal regulations for accident prevention, decontamination or decommission, particularly those in the country where the tool is operated, shall be observed when handling such substances.

**FIRE HAZARD**

Placing objects against the system or covering ventilation slots can lead to a build-up of heat which can damage units inside the microscope or its components and, in extreme cases, may cause fire. Always keep ventilation slots clear and make sure that no objects enter the tool through ventilation slots. In particular this safety advice applies to light sources and their power supplies.

**ELECTRICAL HAZARD**

The power cable shall be connected to a supply featuring an intact grounding (earth) contact. The grounding effect shall not be made ineffective by a supply cable which does not have a protective ground wire.

After any removal of covers, the tool shall not be put into operation, since there will be a risk of electric shock if live components are touched. Always disconnect the tool from the line by means of the mains switch before opening the tool and before exchanging fuses, lamps etc.

Make sure to use only fuses of the rated power. The use of makeshift fuses and the short-circuiting of the fuse holders is not permitted.

For safety reasons, minimum workspace for any kind of installation and maintenance work should be 914 mm in the direction of access to live parts.

The Axiotron 2 is equipped with fuses also in the neutral wire.

**LIGHT OF EXTREME INTENSITY, UV RADIATION**

The optionally available high-power light sources generate light of extremely high intensity. It is not allowed to remove any covers or parts of the illumination assemblies, such as light guides, adapters, mirrors or lamps from the system, unless the system has been shut down properly before.

**PERSONAL PROTECTIVE EQUIPMENT REQUIRED**

Whenever an arc lamp house cover is to be opened, wear personal protective equipment (PPE), such as gloves and a solid face shield that also covers neck and throat.

SAFETY NOTES ON ARC LAMPS

Illuminants used in arc lamp illuminators (which are all light sources with a name that begins with HBO..., XBO..., HXP..., HgXe... or Medexxa) may be under very high internal pressure even when they are cold. Transport and storage of the illuminants is allowed in their original manufacturer's package only.

Arc lamp illuminants are sensitive components and may comprise fragile ceramics sockets. Rough handling or incorrect insertion may damage or even destroy the illuminant, or cause an early failure. Inappropriate handling of illuminants may lead to serious injuries caused by a burst of the glass bulb.

During operation, illuminants may reach temperatures of 950°C and a pressure of up to 100 bar. Upon exchange, the light sources must be given sufficient time to cool down before the removal of any lamp house cover.

Illuminants soiled by grease or fingerprints must not be installed. Before installing such an illuminant, it is required to thoroughly clean the glass body with a lint-free cloth and an appropriate solvent, such as acetone or IPA.

Any modification or repair of the power supply is not allowed. Arc lamp illuminators require high voltages of up to 20 kV for ignition, which may pose a serious risk to life if an improper repair is attempted or if the lamp houses are operated in open condition. If a defect with an illuminator occurs, always call an authorized HSEB Service Representative.

Never reset a lamp life counter without having the illuminant exchanged. Exceeding the permitted lamp life time increases the risk of burst to the illuminant.

Never operate an arc lamp illuminant outside the lamp house for which it has been designed.



2.2 Notes on Warranty

The Axiotron 2, manufactured by HSEB Dresden GmbH, is delivered in perfect functional condition. The manufacturer guarantees that the system has no material and/or production defects when delivered.

In the unlikely event that a defect is found on delivery, the manufacturer shall be informed immediately and the customer is obliged to do whatever necessary to minimize the damage. The manufacturer's obligation to rectify a failed system includes the right to decide whether it is done by repairing the system or by delivering another system. No warranty is provided for defects caused by natural wear (wearing of consumables in particular).

The system manufacturer will not accept liability for damages caused by faulty operation, unauthorized use, vandalism, negligence or any other meddling with the system, particularly the removal or replacement of system components and/or the use of accessories and/or spare parts (inclusive consumable parts) from other manufacturers. In these cases all claims against warranty are forfeited.

The system manufacturer will not accept liability for damages caused by a „Force Majeure“ case including but not limited to acts of terrorism, strike, operator error, war, civil war and similar events.

With the exception of the work specified in this manual, no maintenance or repair of the system shall be performed. Repairs shall only be carried out by HSEB Dresden GmbH

Service Engineers or specially authorized personnel. Should any defect occur with the system, please contact HSEB Dresden GmbH or a local HSEB Dresden GmbH Representative.

For details of specific warranty issues concerning this particular system refer to the documentation related to the purchase order.

2.2.1 Contact Address

The main point of contact for all requests regarding the Axiotron 2 is the HSEB headquarters in Dresden, Germany.

HSEB Dresden GmbH
Manfred-von-Ardenne-Ring 4
01099 DRESDEN
Germany

phone +49 (0) 351 20758-0
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www.hseb-dresden.de



General - Firmenadresse.de

figure 2 HSEB contact data. The QR code can be read electronically and contains the same information.

2.2.2 List of Hazardous Materials

The Axiotron 2 uses the following substances, which are potentially hazardous to the environment. Take care to observe all regulations applicable in the country, community or factory the tool is located in.

- **Mercury:** The optional high power microscope illuminator „HXP“ is equipped with an illuminant that contains about 20 mg of mercury.
- **Lead:** Printed circuit boards inside the Axiotron 2 may be soldered using lead alloys.

There are no other hazardous materials, such as cleaners, coolants or lubricants, which are required for the common use of the Axiotron 2. During service work, minor quantities of lubricants, such as vaseline may be required. According information can be found in the service documentation.

2.2.3 List of Items That Become Solid Waste

In the Axiotron 2, illumination may be provided by high-pressure mercury or mercury-xenon arc lamps. As explained above, these lamps may contain mercury. Furthermore they are under high internal pressure. For the disposal of such lamps appropriate measures need to be taken.

2.3 Specification



NOTE

The official values in this manual are expressed in *The International System of Units*.
The specifications below include all components, functions and contrast modes, no matter if they are included in standard delivery or only as an option.

2.3.1 General Specification

- Mechanical
 - dimensions: see 'Footprint' on page 15
 - weight: approx. 30 kg
 - earthquake protection: anchor bolts are provided, which allow to firmly mount the microscope on the workbench.
- Electrical
 - rating: 115V/230 V $\pm$ 10% single phase AC, 50/60 Hz
 - power consumption: max. 300 VA
 - power connector: IEC320
- Environmental
 - relative humidity: 30% ... 80% r.h.
 - temperature range for operation: +15°C ... +30°C, for transport: -25°C ... +55°C
 - ambient air pressure: 800 hPa ... 1,060 hPa
 - cleanroom class: ISO Class 2
- Shipping Crate Dimensions and Weight
 - Axiotron 2 microscope
 - 670 mm (W) x 660 mm (D) x 1,000 mm
 - total weight: 100 kg (85 kg net)
 - motorized sample stage
 - 660 mm (W) x 540 mm (D) x 220 mm
 - total weight: 19 kg (9 kg net)
 - CSM Module
 - 900 mm (W) x 410 mm (D) x 350 mm
 - total weight: 20 kg (18 kg net)

2.3.2 Microscope Specification

- Field of view
 - 25 mm at eyepieces
 - 21 mm at Axiotron 2 camera port
 - 18 mm with installed CSM
 - the effective field of view available of the camera depends on the chip size
- Reflector revolver
 - motorized and coded, with 4 positions
- Objective revolver
 - motorized and coded, with 5 positions
- Control panel functions

- brightness
- aperture diaphragm
- analyser
- objective revolver
- contrast technique (reflector revolver)
- Parcentricity, Parfocality
 - objective-dependent, programmable correction
 - parfocality only available with motorized or laser autofocus
 - parcentricity only available with motorized stage and MCU28 stage controller
- Contrast techniques
 - BF (brightfield in reflected light)
 - BF (brightfield in transmitted light)
 - DF (darkfield)
 - DIC (differential interference contrast according to de Sénarmont)
 - CSM (white-light confocal imaging with extended depth of focus)
 - CSM-UV (narrow-band i-line confocal imaging)
 - FL (fluorescence)
 - UV (i-line, 365 nm)
 - DUV (deep ultraviolet, 248 nm)
 - NIR (near infrared brightfield in transmitted light)
- Objectives (max. 5 objectives of the following list may be selected)
 - EC Epiplan-Neofluar (5x, 10x, 20x; 50x, 100x; for BF, DF, DIC, CSM)
 - LD EC Epiplan-Neofluar (50x, 100x; for long working distance in BF, DF, DIC)
 - EC Epiplan-Apochromat: (50x, 100x; for BF, DF, DIC, CSM)
 - EC Epiplan-Neofluar (1.25x, 2.5x, 150x; special provisions may apply)
 - 365 nm and 248 nm objectives with 120x magnification (optional)
 - N-Achromat and Epiplan objectives available for special applications
 - see HSEB publication on objectives, which is available separately
- Microscope stage
 - manual or motorized
 - for reflected and transmitted light
 - maximum travelling range is 200x200 mm
 - an extension of the horizontal travelling range, such as to 300 mm is possible, but requires safe fixture of the microscope on the workbench
- Focus drive
 - manual and motorized sample focussing
 - manual focus: 1 μm /division
 - motorized focus: 20 nm encoder resolution, actuated by focus hand wheel at the control panel
- Autofocus
 - real-time dual beam laser triangulation system
 - 256 pixel CCD sensor
 - wavelength 785 nm
 - laser diode power: 5 mW cw
 - class 1 laser device when used in intended manner
 - measuring interval 20 ms
 - programmable offset
 - spot size approx. 3 μm (with 100x objective and in focus)

2.3.3 Illuminators

- Illumination (default, VIS, CSM, film thickness)
 - HAL100 lamp, incandescent halogen lamp
 - remote-controlled by internal power supply
 - colour temperature 3.200 K (at 11.5 volts)
 - luminous flux 3.100 lm
 - luminous surface 3,2 mm x 3,2 mm
 - service life 50 hours to several hundred hours, depending on intensity
- Illumination (optional, BF, DF, DIC)
 - remote-controlled high power xenon (Medexxa) or metal halide (HXP) illuminators
 - attached via liquid light guide and collimator
 - service life is 1.000 hours (Xenon) ... 2.000 hours (metal halide)
- Illumination (optional, CSM VIS)
 - XBO75 xenon lamp
 - continuous, not dimmable (intensity regulation by means of grey filter slider)
 - service life approx. 400 hours
- Illumination (i-line BF, CSM VIS-UV)
 - HBO103, wavelength 365 nm
 - continuous, not dimmable
 - connected via UV cold-light mirror to the microscope, to exclude thermal effects of the light source
 - service life approx. 300 hours
- Illumination (DUV BF)
 - HgXe100 lamp, wavelength 248 nm
 - continuous, not dimmable
 - connected via UV mirror in order to exclude thermal effects of the light source
 - service life approx. 1.500 hours

2.3.4 Accessories and Optional Modules

The following options are available to the Axiotron 2 microscope:

- Confocal Scan Module for either or both visible light and 365 nm (i-line)
- Differential Interference Contrast
- Film Thickness Measurement

Applications using DUV require a different stand body and cannot be retrofitted in the field.

2.4 Footprint

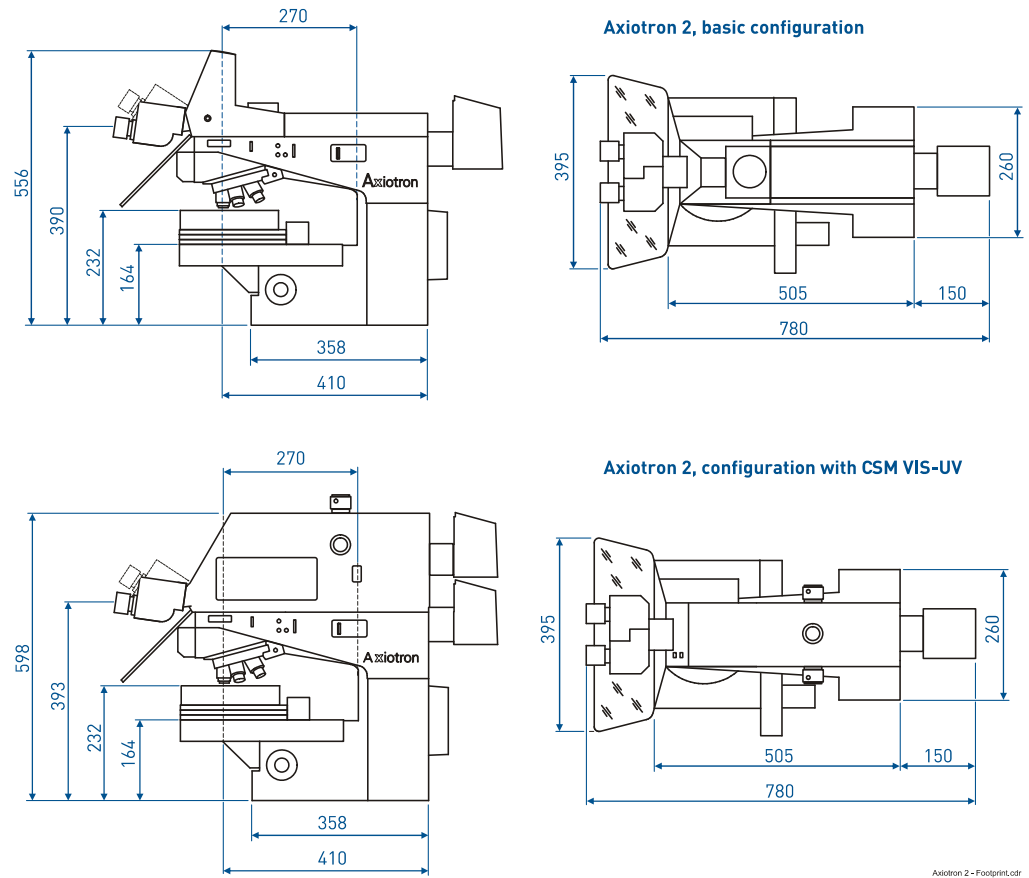


figure 3 Footprint of Axiotron 2, stand-alone and with CSM module

3 MAIN COMPONENTS DESCRIPTION

3.1 Axiotron 2 Microscope

The drawing in figure 4 shows the major components of the Axiotron 2.

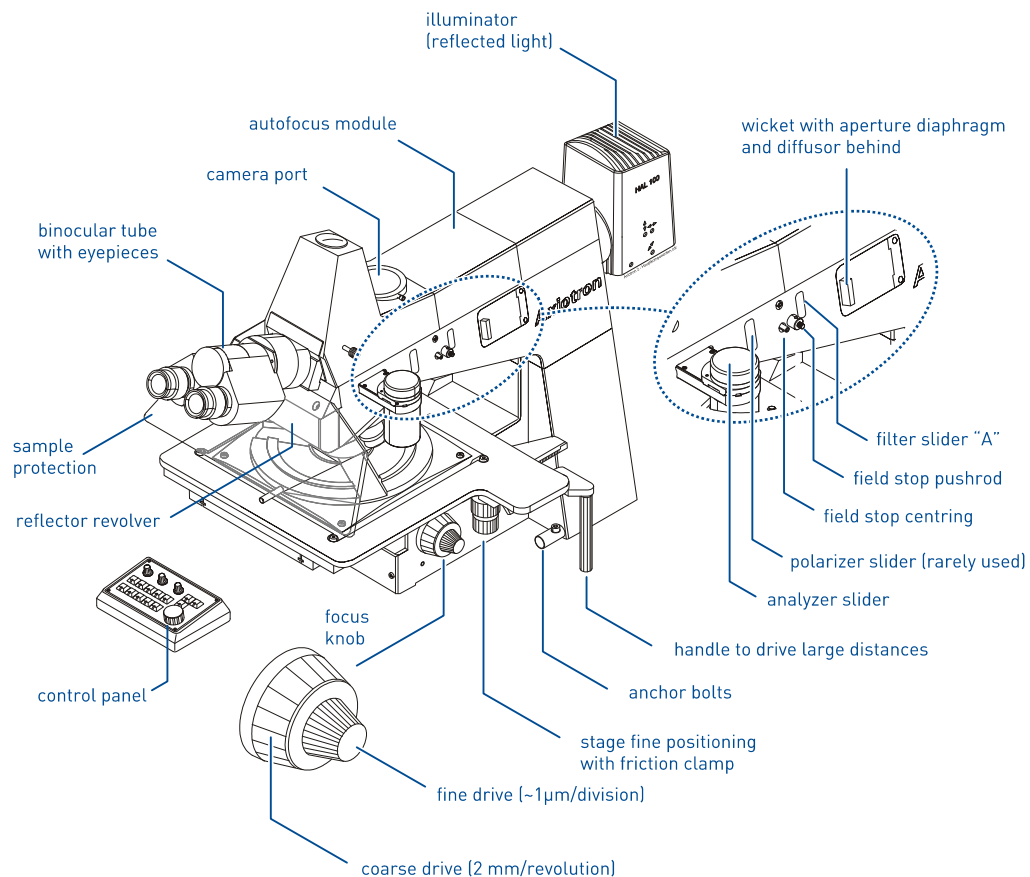


figure 4 Main components of the Axiotron 2

3.1.1 Binocular Tube with Eyepieces

The Axiotron 2 is equipped with a binocular tube, that delivers an upright and unreversed image. It is mounted by means of a dove-tail adapter, that is held by a 3 mm allen screw. The binocular tube features a camera port and a binocular viewport. As the number of optical outputs is - strictly spoken - three, this kind of tube is sometimes also called „trinocular“.

The *camera port* delivers the intermediate image with a diameter of 25 mm (Axiotron 2) or 16 mm (Confocal Scan Module). In the Axiotron 2, several optical components in the tube delimit the useable diameter of the camera image to ~21 mm.

The binocular tube is equipped with two *swivelling mechanisms*, that allow to incline the binoculars between an angle of 5...30 degrees to the horizontal plane, which is very useful for adapting the height of the binoculars to the individual optimum for every

user. In the same manner, the distance between the eyepieces can be adjusted by pulling them apart.

The binocular tube accommodates two *eyepieces*, which are in most cases of the type *PL 10x/25 mm*. They feature an internal magnification of 10 times and a field number of 25 mm. These figures are helpful to determine the field of view at the sample plane as well as the amount of information available. Refer to "Magnification and Resolution" on page 38. More information on eyepieces can be found in "Eyepieces" on page 34.

In Axiotron 2 microscopes, which are equipped with a laser autofocus, the optical/mechanical part of the autofocus is located in a box, that is attached at the rear of the tube, behind the camera view port. The optics box is clearly marked with laser warning labels that indicate the presence of a laser class 3 device inside.



NOTE

Never unscrew and lift the autofocus tube while the microscope system is under power. At the dove-tail adapter of the binocular tube, invisible laser radiation may be emitted. Also, never open the autofocus box that is marked with laser warning labels.

If the box is closed and the microscope is used in the intended manner, the system is classified as a class 1 laser device and it is safe to operate it.

binocular tube	P/N
phototube without laser autofocus	9452-93200
tube extension for above phototube	9452-84500
phototube with laser autofocus	9452-93191
phototube with laser autofocus, but without binoculars	9010-38718
tube extension for above phototubes	9452-84400
binocular extension, eyepieces are 40 mm closer to operator	9452-93297

3.1.2 Diffusor

The diffusor is used to homogenize the distribution of the lamp intensity. Although the microscope is designed to follow Köhler's illumination principle, the filament of the halogen lamp still may show through in the sample plane. Especially for brightfield, the diffusor can be swivelled into the beam path to obtain an evenly illuminated image.

To swivel the diffusor in, open the wicket, insert a 3 mm allen key and turn it clock-wise by about 90 degrees.

3.1.3 Aperture Diaphragm (Reflected Light)

The aperture diaphragm is required to obtain a trade-off between contrast and resolution in the microscopic image. For brightfield imaging at high magnifications, the setting of the aperture diaphragm is crucial; whereas for most other contrast modes, the aperture plays a secondary role.

Behind the wicket, adjustment screws can be found, that serve to centre the diaphragm and to shift it along the optical axis. Please refer to "Microscope Adjustment (Köhler Illumination)" on page 56 for details.

3.1.4 Filter Slider A

The filter slider A may contain a colour filter with 18 mm diameter. By default, a GG475 filter is mounted, which provides a yellow illumination, that is especially suited for observing resist structures. Other options are for example conversion filters 3200K-5500K, which convert the colour temperature from halogen to daylight; or a green filter to enhance the image contrast for b/w photography.

filters and filter sliders	P/N
filter slider A, accommodates one filter	9446-47500
yellow filter, GG475, 18 mm diameter	9347-12000
daylight conversion filter, 18 mm diameter	9467-85400

3.1.5 Field Stop Pushrod (Reflected Light)

This pushrod serves to adjust the diameter of the field stop. For normal observation, the field stop is set to a diameter, which is slightly bigger than the eyepiece's field of view or the camera image. In order to find the focal plane, the field stop can be closed to minimum, as it can be clearly seen and will be shown in focus in the same plane as the specimen. To facilitate the correct setting after focussing, the pushrod is equipped with an adjustable ring, that prevents the pushrod from being pushed in too far, which would result in a too wide field stop setting. The position of the ring can be changed after slackening a set screw.

3.1.6 Field Stop Centring Screws (Reflected Light)

The centring screws are needed if the field stop does not run concentric to the eyepiece. After inserting a 3 mm allen key, the field stop can be moved and centred. It is important to know, that the direction of move is not horizontal/vertical, but approx. under 45 degrees angle. More details can be found in "Microscope Adjustment (Köhler Illumination)" on page 56ff.

3.1.7 Polariser Slider

The Axiotron 2 features a slot which allows to insert a polarising filter, such as for polarisation microscopy. However, the most-used contrast mode with polarised light, which is *Differential Interference Contrast*, uses a filter cube with a built-in polariser, so that this slot is usually covered with a plastic plug.

The two versions of polarisers that would fit in are have the P/N 453607 (fixed) and 453610 (variable).

3.1.8 Analyser Slider

Here, for Differential Interference Contrast, a filter slider with a polarising filter can be inserted. There are two versions available, one for pure manual and one for motorized operation. However, both need to be inserted/retracted manually. The motorized filter is connected to the stand by a tiny round connector just below.

The analyser slider needs to be inserted whenever Differential Interference Contrast is used. It may stay at Brightfield, but it must be retracted in any other contrast mode (BF, CSM, UV, FL).

To remove the slider, it is first necessary to slacken the set screw that is hidden behind a hole in the cover of the reflector revolver. Unscrew the set screw using a 3 mm allen key and disconnect the cable before removing the analyser.

analyser sliders	P/N
motorized analyser slider, pre-programmable position	9453-66491
manual analyser slider	9428-10300

3.1.9 Reflector Revolver

The different contrast modes are optically set by means of so-called reflectors, that contain several optical elements (mirrors, filters, optics, polarisers) which shape the light according to the required imaging technique. To exchange reflector cubes and also for a comprehensive list of available types, refer to "Install Reflector Cubes" on page 71ff. At maximum, four cubes can be installed.

3.1.10 DIC Sliders

Above the objective seats, in the objective revolver there are slots that accommodate the Wollaston prisms for Differential Interference Contrast. If there is no prism installed, a plastic dummy insert closes the slot and protects the objective back aperture from exposure to dust.

Please refer to "Setup Of Differential Interference Contrast" on page 63ff for details on the way how DIC prisms are installed and adjusted. Each objective requires a particular type of DIC slider.

3.1.11 Objectives

The Axiotron 2 features five objective positions. All objectives used with the Axiotron 2 must be of the ICS (infinity-corrected) system. The standard objective thread is *M27x0.75*. Objectives, which are not capable of darkfield, may be equipped with a *RMS W 0.8 x 1/32"* thread. For these objectives, an adapter (P/N 9010-95168) is available.

There are several objective lines, that are well suited for the Axiotron 2:

- The *Epiplan-Neofluar* line is the best choice for a trade-off between price and quality. They have been especially designed for the examination of materials. A high NA and, thus, a higher resolving power are combined with an optimization for highest contrast (EC-Series). They are also suitable for transmitted-light microscopy. Due to their strict telecentricity on the object side, these objectives are well suited for measuring purposes. Epiplan-Neofluar objectives are also available in a long working distance series.
- The *Epiplan* series is not as sophisticated with regard to their optical properties as the Epiplan-Neofluars, but their excellent transmission factors make them very useful for darkfield applications. Whenever darkfield is the main application, these objectives offer a substantial gain of image detail.
- Objectives of the *N-Achroplan* series are best suited for near infrared applications, such as for the inspection of wafers in transmitted light. Their excellent transmission quality surpasses all other objective lines for this particular type of inspection.
- The *Epiplan-Apochromat* objectives are the top-of-the-line objectives for inspections in the visible range of light. These high-power, apochromatically corrected objectives for reflected light satisfy the most exacting demands in material microscopy. They feature sufficiently high transmission in the 400...700 nm spectral range. Due to

their strict telecentricity on the object side, these objectives are ideal for measuring purposes. Epiplan-Apochromat objective are also required for the use of the CSM module.

- *Ultrafluor* objectives are used for i-line and DUV inspection. They are available in broad-band versions as well as with a very narrow transmission spectrum, thus allowing an excellent, distortion-free imaging quality while suppressing stray light caused by undesired fluorescence.

3.1.12 Anchor Bolts

To affix the Axiotron 2 on a workbench, two anchor bolts can be attached to both the microscope and the table. This measure may become necessary if the microscope is operated together with a wafer loader (so that the position between loader and microscope needs to be maintained) or if the microscope is equipped with a heavy and cantilevered 300 mm sample stage, which might impair the mechanical stability of the microscope stand.

3.1.13 Cameras

A list of suitable cameras would go well beyond the scope of this handbook. If an image acquisition system is to be planned for a stand-alone microscope, the first decision is, whether a real *live image* with 25 or 30 frames per second is important - this would be the case in all applications, in which the optical feedback between sample and operator would take place rather on a computer monitor than in the eyepieces - or if *high-resolution still images* are the first choice.

- *Live cameras* follow the PAL or NTSC standards and are available with a chip size of 1/3", 1/2" and 2/3". Zoom adapters may be used to reduce the „keyhole“ effect that causes the cameras to see only a small part of the image that is visible in the eyepieces. Such live cameras are available for visible, i-line and NIR imaging. There are also live digital cameras available.
- *Still cameras* are available in an almost infinite variety. Here, the main purpose (wavelength, resolution, sensitivity) should be the start point for selection. It is always a good idea to keep an eye on the optical interface, which should preferably be a C-Mount.

3.1.14 Camera Port

For cameras or metrology systems, such as for film thickness measurement, the Axiotron 2 features a camera port. This port is a Zeiss-proprietary dove-tail adapter with 44 mm diameter. Several adapters with or without zoom factor are available. The most common adapters for industry-standard cameras with C-Mount are listed below. The first entry in the list, P/N 9452-99500, is the first choice to connect any C-Mount based camera to the Axiotron 2.

adapter	P/N
standard adapter (1.0x; 2/3" CCD chips, C-Mount)	9452-99500
camera adapter for DXC950 (1.0x)	9010-71710
camera adapter for digital cameras with M52x0.75 filter thread	9011-08984
zoom adapter (0.5x...2.4x; 1/2" CCD chips, ENG)	9452-98400
camera adapter (4x re-magnification, for 1-chip-CCD cameras)	9452-98500
zoom adapter (0.33x...1.6x; 1/3" 3-chip CCD, C-Mount)	9452-98900

adapter	P/N
camera adapter (0.63x, 1/2" CCD, ENG)	9455-02600
camera adapter (0.63x; 1/2" 3-chip-CCDs, ENG)	9459-99200
camera adapter (0.63x; 2/3" CCD, C-Mount)	9452-99700

The CSM module features three camera ports, which can be activated by a button on the CSM head or by a software command. The CSM ports have a different form factor than the binocular tube's ports. Below you can find a list with possible camera adapters.

adapter	P/N
camera adapter (1.0x, ENG bayonet, centrable)	9010-46116
camera adapter (1.0x, 2/3" CCD chips, C-Mount)	9010-69414
camera adapter (1.0x; C-Mount)	9010-69415
camera adapter (1.0x, for DXC950 with 1/2" CCD chip)	9010-71709
camera adapter (1.0x; 2/3" CCD, centrable, for CSM VIS-UV)	9010-72457
camera adapter (1.0x; 2/3" CCD, centrable)	9456-11100

There is also a wide range of adapters available, that help to connect digital cameras, such as SLRs to the microscope. To find a matching adapter for your camera, contact a HSEB applications representative.

3.1.15 Illumination Port (Transmitted Light)

The Axiotron 2 requires a second light source to be attached to the transmitted light unit. Like all illuminators used with the microscope, it can be attached to the dove-tail adapter provided.

As the transmitted light illuminator is located close to the operator's left hand, usually a remote light source (Schott KL1500, KL2500) is used together with a flexible light guide and a collector adapter.

Alternatively, especially when the microscope is used in infrared transmitted light, a common halogen lamp HAL100 with an extension tube is used.

3.1.16 Transmitted Light Unit

The transmitted light unit basically contains a diffusor (similar to the diffusor disk in the reflected light beam path), a 45 degrees mirror and the field stop assembly.

3.1.17 Field Stop (Transmitted Light)

The field stop is located on top of the transmitted light unit. It comprises an iris diaphragm, which can be opened and closed by turning the plastic ring on top of it. As - in contrary to the reflected light beam path - the individual objective's optics is not used for the illumination of the sample, the field stop diameter needs to be adjusted anytime an objective is changed. The illumination adjustment according to Köhler's principle needs to be repeated for every individual magnification.

The field stop can be centred by means of two screws in the condensor optics. For details see figure 5.

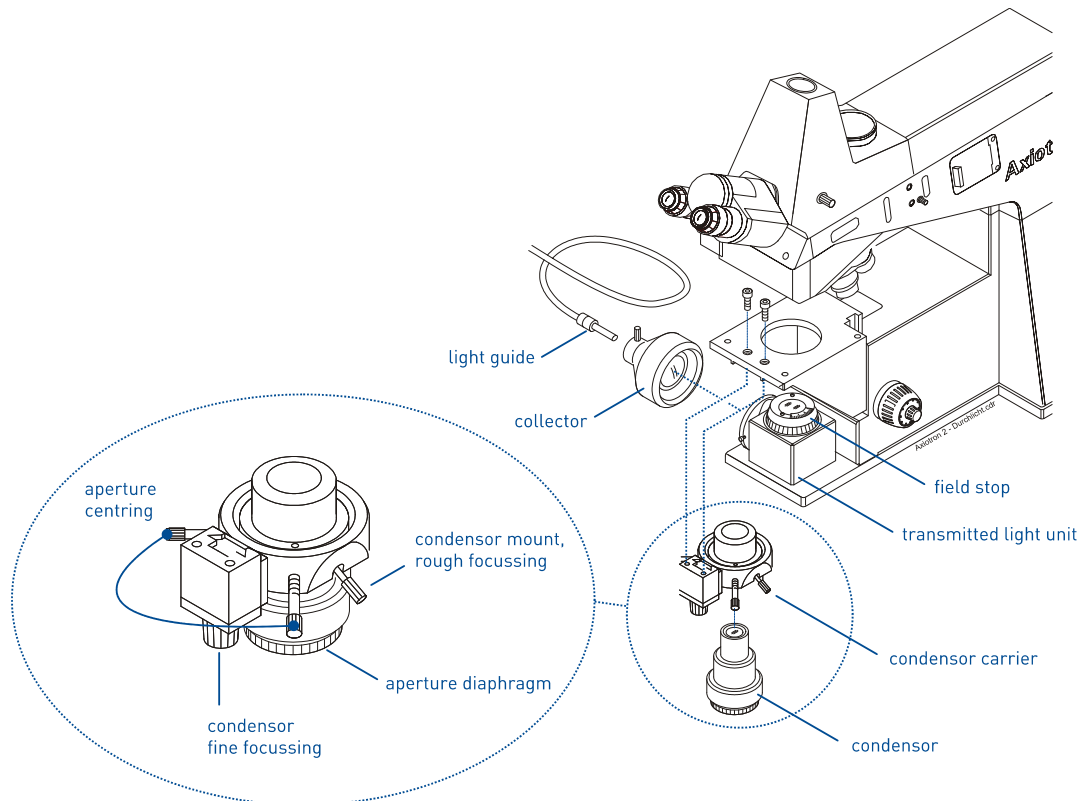


figure 5 Additional components for transmitted light operation

3.1.18 Condensor

The condensor is required to obtain a crisp image of the field stop in the sample plane. Additionally, it comprises the aperture diaphragm, which is required to adjust the necessary trade-off between contrast and resolution. By means of two centring and one lateral focussing screw, the position of the condensor can be changed. Refer to “Köhler Illumination in Transmitted Light” on page 59 for details.

3.1.19 Aperture Diaphragm (Transmitted Light)

The aperture diaphragm is part of the condensor assembly. On its lower part there is a knurled ring, which can be rotated in order to open and close the aperture.

3.1.20 Illumination Port (Reflected Light)

The light source for all reflected light modes except CSM is attached here. For common stand-alone application, the halogen lamp HAL100 (P/N 9423-09901) is the first choice. However, there are some other light sources, as the Schott KL1500 (P/N 9010-63181), KL2500 (P/N 9010-63183), Medexxa LG-Xe 180 W remote (P/N 9010-33896) or the HXP 120 light source (P/N 2900-00001), which may be attached to the microscope as well. It is also possible to connect a manual or motorized switching mirror to the illumination port and to connect two light sources, which are engaged depending on the image mode that is currently used.

If a third-party light source is to be attached, a basic requirement is that the active diameter of the light guide shall not be bigger than 5 mm. In this case, use a collimator with P/N 2048-10080 to attach the light source.

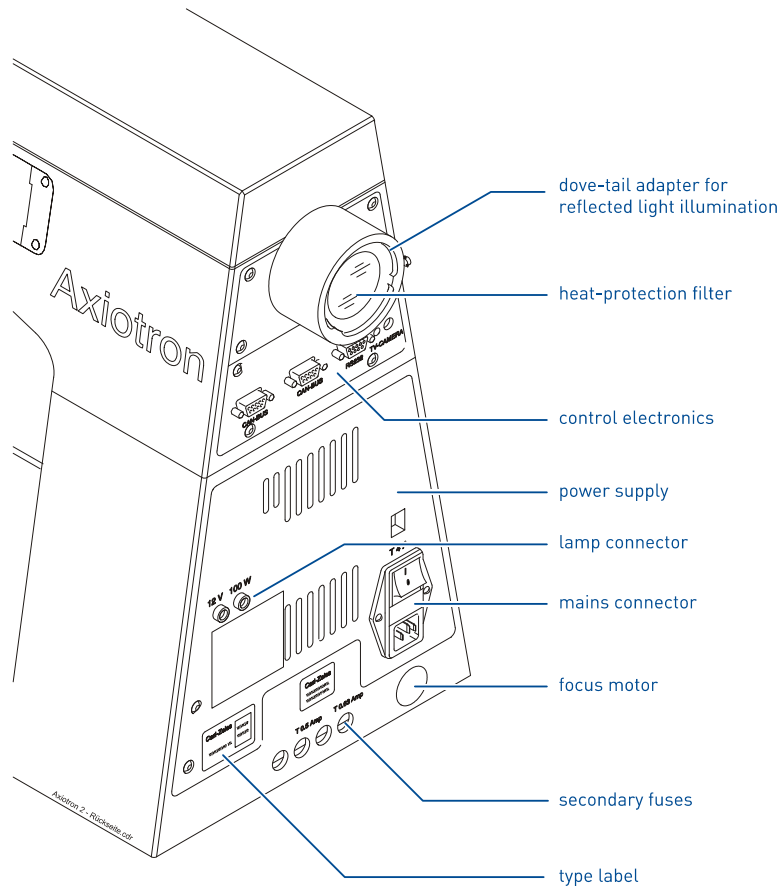


figure 6 Microscope back side

3.1.21 Heat Protection Filters

This filter blocks all wavelengths above 750 nm and keeps the interior of the microscope cold, which is a clear benefit with regard to thermal and optical stability.

For infrared applications, the heat protection filter needs to be removed, also from the light sources attached, as some of them (including the HAL100) are also equipped with such kind of filter.

Vice versa, if the laser autofocus is used, both filters must be present, as the autofocus laser wavelength lies in the range above 750 nm and cannot be detected without the filters in place.

3.1.22 Lamp Connector (Reflected Light)

The main light source can be controlled by the microscope firmware. If a halogen lamp is used, it can be directly connected to the **12V 100W** jack at the back of the microscope. Other lamps can be remote-controlled with an analogue signal between 0...5 Volts.

3.1.23 Control Electronics

The electronics controls all motorized components of the Axiotron 2 (objective and reflector revolver, light intensity, aperture and analyser setting, optional switching mirrors) and provides a set of predefined optimized values for every objective/reflector combination that help to start every microscopic inspection with optimized settings. The optimized values are stored in a battery-buffered memory inside the control electronics.

Furthermore, the electronics provides a CAN- and a RS232 interface to communicate with other components of the Axiotron 2 systems family (laser autofocus, motor controller MCU 28, transmitted light controller, CSM module, microscope control panel) and with a computer for remote control and parameter modification, upload and download.

The microscope is also equipped with a feedback jack to automatically regulate the lamp intensity depending on the output level of a video camera. This is especially helpful on samples with strongly varying reflectivity in conjunction with CCIR b/w cameras. With colour cameras, the change of colour temperature in halogen lamps depending on the operating voltage may cause more problems than benefit.

3.1.24 Mains Connector

There are two versions of power supplies for the Axiotron 2 available.

Older versions, which were delivered until approx. 2001 were available with a switchable power supply, that needed to be adjusted to either 110V or 230V. These microscopes featured a slide switch above the power connector and a set of four secondary fuses at the bottom of the back side.

Newer versions of the microscope are equipped with a wide-input-range power supply. They can be easily recognized by heat sink ribs protruding from the back side. Microscopes with this newer version of power supply, are neither equipped with the voltage selector switch nor with the secondary fuses.

3.1.25 Focus Motor Jack

Microscopes, that are equipped with either a motorized focus drive or with a laser autofocus are connected to the motor controller by means via this connector. The focus motor jack is only mounted if the motor assembly is installed. This can be recognized easily by checking the left side of the focus drive. If there is a knob, the microscope is equipped with a manual focus, If there is a cover with two brass gears behind, the microscope is prepared for motorized focus operation.

3.1.26 Type Label

On the type label a six digit number can be found, that usually starts with 7xxxxx. This is the serial number of the microscope. Use this number for all inquiries regarding spare parts or repair.

3.2 Microscope Control Panel

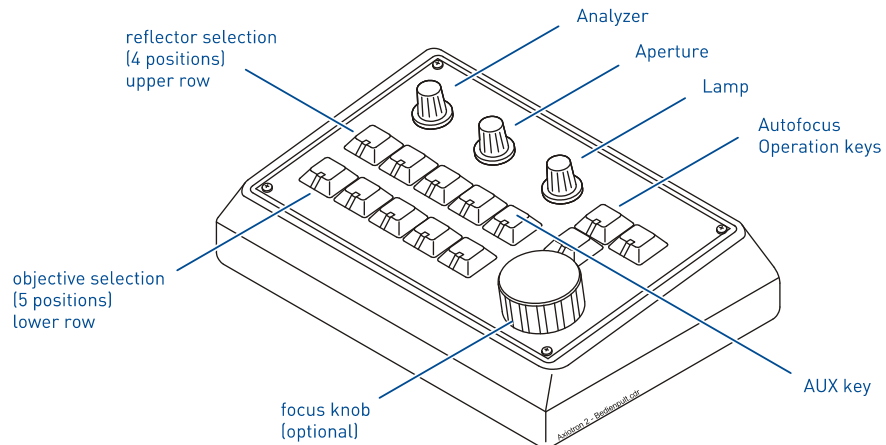


figure 7 The microscope control panel.

3.2.1 Analyser

The analyser knob is required to adjust the amount of interference contrast for imaging of samples in DIC mode. If no DIC mode is installed or active, the knob does not have a function. Some Axiotron microscopes with CSM, that were delivered in the 1990s may be equipped with a mechanical attenuator for the CSM light source. On these systems, the analyser knob would control this attenuator.

Unless a new default setting is stored, the factory-set optimum defaults are recalled anytime a certain objective/reflector combination is selected, independent of the actual knob position. Pressing **AUX** is required to release the knob. If the knob is touched after release, the analyser position will follow the knob position until another objective/reflector combination is selected. See the section on the **Aux** key below for details.

3.2.2 Aperture

The knob acts on the aperture diaphragm in the microscope. This optical element provides a trade-off between contrast and resolution.

The smaller the diameter (i.e. the more the knob is turned to the left), the better the sample contrast becomes. On the other hand, a smaller diameter affects the resolution capability. Therefore it is definitely **not** recommended to close the aperture in order to adjust the lamp intensity. Use the **Lamp** knob instead.

Regarding the predefined factory settings and its temporary and permanent changes, refer to the information provided above with respect to the aperture knob.

3.2.3 Lamp/Brightness

This knob allows an adjustment of light intensity for the visible light range. It works with halogen lamps (HAL100) and the high-power light generators (Medexxa, HXP), but not with UV arc lamps like HBO103 or HgXe100, as these light sources cannot be dimmed.

The lamp potentiometer bears a mark on its knob, that corresponds with a mark at the control panel. If the potentiometer is on that position, on changing objectives and/or reflectors the lamp intensity corresponds with the pre-programmed value in the micro-

scope. Turning the knob changes the lamp intensity value as well, but (1) immediately after touching it, which means, that the *AUX* key does not need to be pressed before and (2) the adjustment range is not adjustable from zero to maximum, but only *half of the total possible range*.

As a result, it is possible, that turning the knob of the lamp potentiometer to the right might not result in a maximum light intensity. The maximum of light intensity that can be adjusted during common operation is always the pre-programmed intensity for the given objective/reflector combination plus half of the total possible range. To set the intensity to other values, it is necessary to get into teach mode; the teach mode offers the full adjustment range.

3.2.4 Focus Wheel

The focus wheel acts on the focus drive of the microscope and is manually adjusted to obtain a sharp and crisp microscopic image. It is an optional component and only available if either the motoric focus drive or the laser autofocus is installed.

The maximum sing range is 20 mm and can be set within 40 mm. An adjustable stop limits the focussing range.

The absolute amount in microns by which the focus drive is actually moved for one revolution of the focus wheel cannot be predicted. It depends on the objective magnification and is factory-set to an amount that allows virtually the same haptic „in-focus / out-of-focus“ behaviour, even if the focal depth of the lenses differ by magnitudes.

In contrary, the amount by which the focus plane is changed by moving the mechanical fine drive knob is a fixed setting that is independent of the current magnification. Per fine-drive knob division, the stage will move 1.11 microns, which is 200 microns per fine drive knob revolution.



NOTE

Mechanically, the focus drive in a manual Axiotron is a planetary gear that is based on friction between the fine and the coarse drive knob. This means, that there is a possibility of slickage that causes the sample stage not to follow exactly the movement of the fine drive knob. Absolute Z measurements are to be trusted only with a pinch of salt for that reason.

3.2.5 Objective Selector

The Axiotron 2 features five objective positions. These are represented by five keys, which are individually marked, depending on the installed objectives.

By selecting an objective, it is possible that light sources, filter cubes or other optical components are automatically activated or de-activated. This behaviour is factory-set to optimise the optical beam path, depending on the imaging task. For example, illuminators for i-line imaging are different from common visible light lamps. If a dedicated i-line objective (that would not be useable in visible light anyway) is chosen, the necessary changes of illumination and filter cubes are accomplished without further operator action.

3.2.6 Autofocus Controls

- Pressing **Define** for 3 seconds (re-)defines the focus plane.
 - Autofocus capability is guaranteed in all visible light modes (BF, DF, DIC, CSM) for the 5x, 10x, 20x, 50x and 100x objectives. Also, when using i-line, the 120x objective with P/N 9011-13342 is autofocus-capable.
 - As the concept of the autofocus in the Axiotron 2 microscope is not to identify, but to track a plane that is defined as „sharp“, any sample plane can be set, even if it is apparently not a sharp image. This also allows to focus on features that are of minor importance or difficult to track otherwise.
 - A successful definition is confirmed if the AF indicator is turned on. A blinking lamp indicates either that no autofocus function is possible with the chosen objective (which can be the case with 1.25x, 2.5x or 150x lenses in particular) or that the sample did not reflect enough light for the autofocus to work properly.
- The **Reset AF** button re-activates the focus wheel, if the focus drive is to be moved beyond predefined soft limits. These limits keep the possible movement range close to the focal plane to make image-finding easier and to prevent a run-off of the focus drive on critical samples.
- Pressing the knob **Autofocus On** will (re-)activate the laser autofocus.
 - If the desired focal plane has been correctly defined before and if the objective is designed to work with the laser autofocus, the focus drive will automatically bring the pre-defined sample plane into focus.
 - If the focal plane is assumed to be beyond the internal soft limits of the autofocus, it is necessary to press the **Reset AF** button.
 - If the autofocus is working, the LED in the key lights up. In this condition, all sample height variations are automatically and instantly corrected. Any movement on the focus wheel will instantly turn the autofocus off (LED extinguishes) and return the command over the focus drive to the operator.
 - Resuming to automatic mode is easily accomplished by pressing the **AF On** knob again.

3.2.7 Contrast Techniques aka Reflectors

These four keys are individually marked depending on the programmed imaging mode.

The Axiotron 2 features four so-called reflector cubes, which can influence the kind of contrast mode, such as BF, DF, DIC, CSM or i-line. Also special applications, such as the activation of a laser marker can be assigned to a function key.

As for the objectives, a selection of a particular reflector may cause to switch light sources, the CSM mode of other optical-mechanical components.

3.2.8 AUX Key, Teach Mode

The AUX key has two functions

- to unlock the knobs for analyser and aperture
- to set the microscope into Teach Mode.

Both modes are described in the sections below.

3.2.8.1 *Unlock the knobs for analyser and aperture*

The control panel is usually placed close to the operator's hand at a convenient place. During operation it will quickly become a habit to operate it blind, i.e. without a visual feedback. This would pose the risk to inadvertently touch the knobs for aperture or analyser. As the optimum settings for both components are duly taught and stored, it would impair the microscope performance if they were changed without reason.

Therefore both aperture and analyser are locked if a certain combination of objective and reflector is selected. The only accessible knob is the *Lamp* knob. If a change of aperture and analyser is required, the knobs need to be unlocked by pressing the *AUX* key. Doing so will cause the previously lit LED inside the *AUX* key to extinguish and to enable both knobs for manual operation.

3.2.8.2 *Set the microscope into teach mode*

All knob positions (or better: the corresponding settings inside the microscope) are stored in the microscope's internal parameter file. Anytime an objective or function key is pressed, the components accessible via these knobs are set to optimized, factory-set defaults. Any changes on the knobs have only a temporary effect. After touching any (or the same) objective or function key, the factory presets are immediately re-loaded.

Permanent changes to the presets can be carried out by pressing the *AUX* button together with either the current objective or reflector button for more than three seconds. The current values for analyser, aperture and lamp brightness for the actual objective and function key combination are stored, but only if they have been touched before.

Now the potentiometers for aperture, analyser and lamp may be adjusted. Refer to 'Microscope Adjustment (Köhler Illumination)' on page 56 to learn, how the microscope is set up correctly. After finishing the adjustment for this particular objective/reflector combination, press the *AUX* key alone again to return and wait about 5 seconds to let the microscope return to normal operation mode.

To teach all (5 objective) x (4 reflector) = 20 possible combinations, the teach mode must be activated for the same number of times, as every teach mode activation acts only on the combination that is currently selected. This is also the reason why it might be useful to keep backups of the microscope parameter file stored on the control computer's hard disk. A method on how to backup and restore parameters to and from the computer is described in 'Backup And Restoring Of Parameters' on page 91.

This means, if only one setting is to be updated (mostly this will apply for the default brightness), the best method is to touch first another and then the required objective or function key once in order to recall the presets, then to adjust the one setting in question and then to store the changes.

When in teach mode, the LED inside the *AUX* button blinks.



NOTE

Please carefully avoid to turn the microscope off or otherwise to lose mains power supply at a time when the *AUX* key is blinking. The microscope would lose all factory defaults in this case, being indicated by blinking of all LEDs at the control panel. Although it will not impose any danger to the instrument, a time-consuming process to re-teach all settings or a service call would be the necessary consequence.

As the software that controls more complex tools (such as SmartVIEW) may allow to include microscope settings into the recipe, it is possible that the behaviour of the microscope changes remarkably if a new recipe is started. The software allows to restore the parameters that have been changed, but as this is an optional setting, it is possible, that after executing a recipe the microscope settings are permanently changed.



NOTE

It is not very difficult to permanently impair the microscope's performance by careless use of the *Define* function. For example, closing the aperture in darkfield mode may result in a completely dark image, as no light can pass through the system. This condition is similar to the above-mentioned loss of the parameter set and would have the same consequences.

3.3 CSM Module

Below the CSM-specific components of an Axiotron with CSM VIS or VIS/UV can be seen. Please find a description of the operator-relevant components below figure 8.

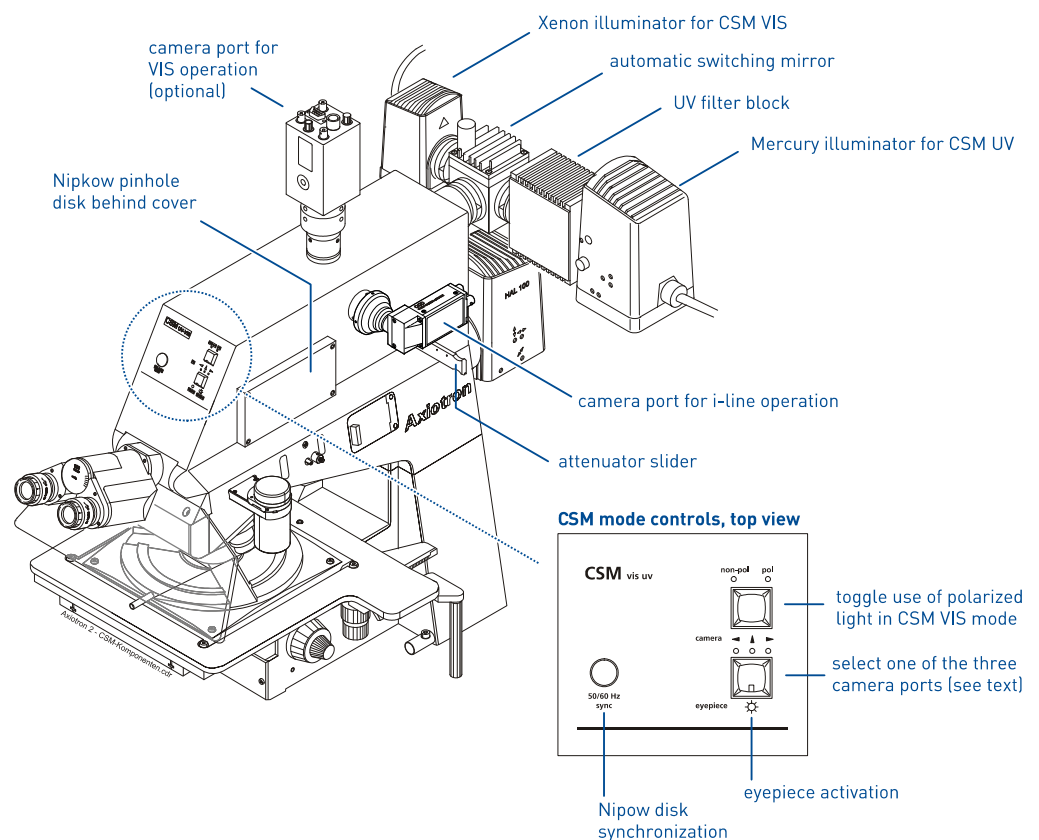


figure 8 CSM-specific components

3.3.1 CSM Controls

The CSM is activated by selecting a predefined reflector key. In almost all installations, reflector number 4 is coded to activate the CSM module.

if the CSM module is activated, the pinhole disk is moved into the beam path and switched on. The control panel commands are redirected to the control electronics in the CSM. Additional control elements in the CSM are activated. If another contrast mode is selected, the above operations are reversed. In this case the CSM only serves as binocular tube with three camera ports.

- The *pol non-pol* knob allows to switch in polarising filters, which cancel undesired stray light in the CSM module and also increase contrast by using polarised light for sample illumination. So far, the *pol* setting increases contrast, but on account of image brightness. If the focus is rather on intensity than on contrast, the *non-pol* setting is the better choice. This knob is only useful in visible light CSM.
- The *camera* button switches the camera revolver to one, two or all three possible positions. Every second time it is switched, it will also activate the eyepieces. Activating the *eyepieces* means, that a beam splitter inside the CSM head is moved to a position which directs more light to the eyepieces. There are CSM heads available with 0% - 100% and with a 30% - 70% splitter, so that the effect has a different impact on the visibility. As it would require six switching operations to go the whole round, undesired camera positions can be excluded from the procedure. Also, for CSM UV mode, for reasons of safety and convenience it is possible to activate a particular camera port for the UV mode exclusively and automatically. If changes with these settings are required, contact a HSEB service representative.

CSM type	P/N
CSM VIS-UV with 30/70 beam splitter, without autofocus	9011-57125
CSM VIS-UV with 0/100 beam splitter, without autofocus	9010-72461
CSM VIS-UV with 30/70 beam splitter, with laser autofocus	9011-57123
CSM VIS-UV with 0/100 beam splitter, with laser autofocus	9010-72460

In the past, there were also versions available, that were not suited for i-line operation. These types bear the Carl Zeiss part numbers 452250 and 452251 and can be recognized by a black potentiometer at the place where the recessed sliding switch *50/60Hz sync* is located today (see figure 8).

3.3.2 Nipkow Pinhole Disk

As explained in the section on CSM imaging (see “Confocal Scanning Mode (CSM)” on page 48), the image is formed by a subsequent pinhole projection in the x/y plane, which is colour coded depending on the sample height. To produce a two-dimensional image, the pinhole needs to be moved across the x/y plane.

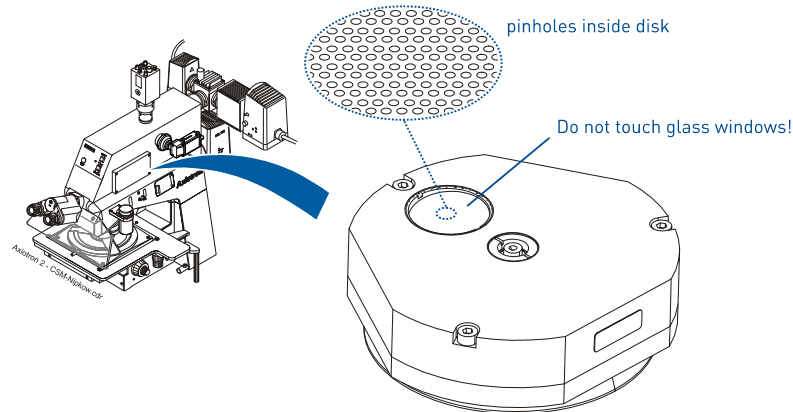


figure 9 Appearance and location of Nipkow pinhole cartridge

Technically, the process of moving the pinhole is accomplished by a rotating glass disk, which is plated with Chromium and which contains about 40.000 pinholes of 70 microns diameter. The distance between the single pinholes is big enough to exclude any stray light from adjacent sample points. The large number of pixels allows to image more than one x/y spot of the CSM image at one time, thus facilitating a real-time imaging with reasonable image brightness. The disk is hidden behind a cover at the CSM module. It is safely stored in a cartridge which protects it from dust and fingerprints. This is essential, as the disk is located in an image plane which is conjugated to the sample, so that any kind of contamination would contribute to the microscopic image.

For the same reason of contamination protection, the disk should not be removed by the user, nor touched or even opened. No maintenance or cleaning is required for this part either.

3.3.3 CSM Illuminator Assembly

The CSM module is illuminated via its own illumination port, which is located at the back of the CSM head. This port is used for the CSM mode only, which means, that even with an installed CSM module, the illumination for BF, DF, DIC, FL etc. is still accomplished via the illumination port at the Axiotron 2 stand below.

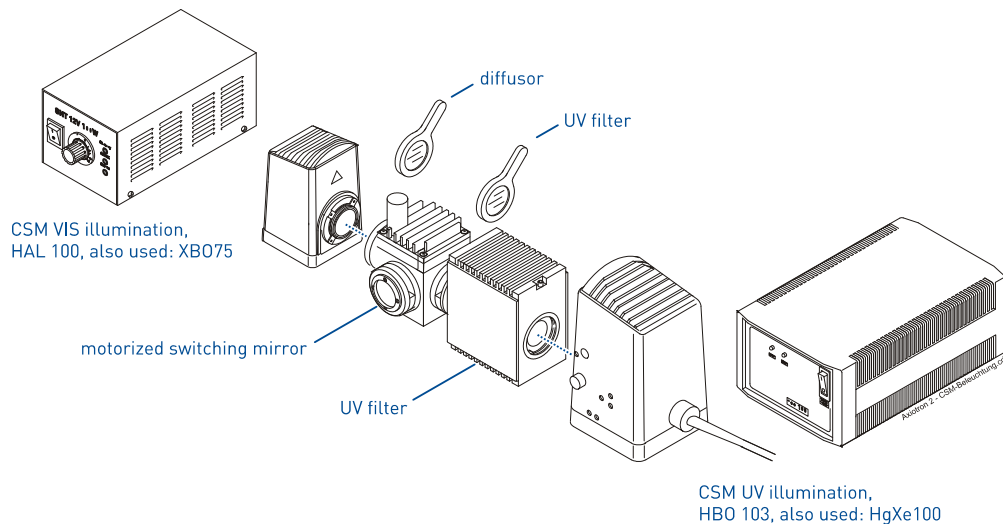


figure 10 Typical CSM VIS-UV illumination assembly

NOTE



Older types of CSM (before 1998, only capable of VIS mode) may have been equipped with a motorized attenuator (P/N 448020). This attenuator was mounted between CSM illumination port and light source and allowed the regulation of the CSM illumination intensity with the help of the *analyser* knob on the Axiotron's control panel, while the CSM was activated. This attenuator, however, did not enjoy too great popularity and is only mentioned for the sake of completeness.

Today, any required intensity regulation is done with a grey filter slider, that is inserted into the CSM head (underneath the CSM UV camera, see figure 8 on page 29).

As the CSM can be operated either in visible light (white-light confocal mode with colour height coding of sample topography) or in UV mode (i-line narrow-band confocal imaging), the presence of either one or two light sources can be necessary. These two light sources can be activated by means of a so-called motorized switching mirror. In most cases, the light sources are powered on at all times, but the illumination port of the CSM head is switched to either the VIS or the UV source.

3.3.4 CSM Cameras

The CSM module features a camera revolver with three ports. All three ports can be configured to be activated for a particular contrast mode or objective position. In general, no particular camera is required when the CSM is operated in VIS mode only. As the image is generated optically and in real time, it may be enough to observe it in the eye-pieces.

For CSM UV, things are different. As the microscope operates on 365 nm wavelength, the image is not visible to the human eye. Furthermore, the UV radiation could damage the cornea. For that reason, binocular vision is deactivated for i-line modes. A i-line sensitive camera is used for the image acquisition.

This camera is usually mounted on the right-hand side camera port. A yellow sticker indicates the side on which the UV camera is mounted.



NOTE

During operation, i.e. when the UV light sources are switched on, the camera must not be removed, as invisible UV radiation will emerge from the camera port.

If the microscope is equipped with a analogue monitor and two cameras, a signal from the microscope that is transferred via a dedicated remote cable will automatically switch the input channels of the monitor, so that the currently active camera is displayed without any further action required from the operator.

3.4 Sample Stages

The Axiotron 2 microscope may be purchased with manual or with motorized stages for reflected and for transmitted light operation.

Stages for reflected light may be equipped with wafer holders (vacuum chucks) for 4, 5, 6 and 8 inch wafers. Recessed concentric rings in the chucks are exposed to fab vacuum, so that the wafer is safely held in place. A manual vacuum switch is used to interrupt the vacuum line and to vent the chuck, so that the wafer can be safely removed. Loading and unloading of wafers can be done for example by means of a vacuum tweezer, that is inserted into a recessed area in the chuck.

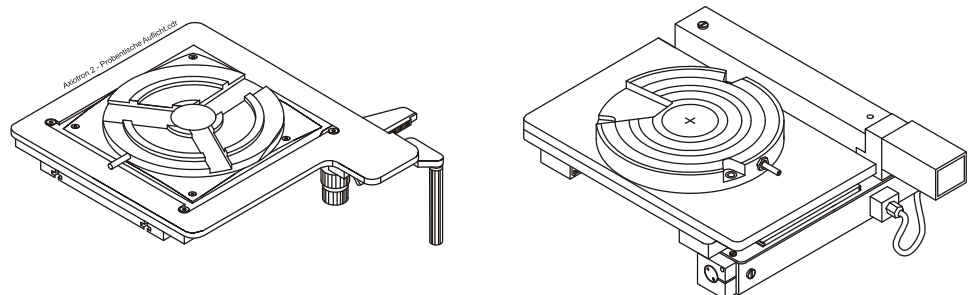


figure 11 Examples for manual and motorized sample stages for reflected light operation

Stages for transmitted light microscopy may be equipped with mask holders for 5, 7 and 8 inch. Also masks with pellicle can be inserted into the holders. Alternatively, a large glass plate allows to place transparent free-form samples and to inspect them.

For particular purposes, any kind of sample stage can be customer-tailored, as long as the travelling range does not exceed 200 mm in the vertical (to/from the operator) direction. For example, 300x200 mm stages are common customizations.

For larger samples, it is recommended to use the Axiotron 2 in the OEM version. This microscope is a modification of the upper stand part and can be mounted for example onto a portal frame, e.g.. from granite, that can have any desired dimension, as long as the mechanical stiffness is sufficient for the desired magnification.

Manual stages may be equipped with a position measuring system. Motorized stages come at least with rotary encoders that allow to read out their position. Some stages even feature an optical position measuring system, but are mainly used in inspection systems.

stage component	P/N
manual stage (200 mm, for reflected and transmitted light)	9413-41100
stage as above, but with positioning measurement system	9413-00000
motorized stage (200 mm, reflected light)	9413-47700
motorized stage (200 mm, transmitted light)	9413-45091

3.5 Eyepieces

Eyepieces are the optical elements that represent the second stage of the composed optical system that make out a microscope. It's basic function is to re-magnify the so-called intermediate image and to provide a virtual image of it to the eye.

In the Axiotron 2, usually eyepieces with a 10x magnification and an intermediate image diameter of 25 mm are used. There are two options available:

- *Focusable eyepieces* allow to equalize differences in vision and allow to observe a microscopic image in binocular vision without having eyeglasses on. Focusable eyepieces can be recognized by a *foc* in the engraved name, such as *PL 10x/25 Br. foc*.
- *Epiplanaric* eyepieces feature a more sophisticated optics to ensure a strict orthoscopic imaging. Barrel- or pin-cushion distortion is compensated; and the image in the eyepieces is sharp from the centre to the periphery. Standard eyepieces are the more economic alternative, however. Epiplanaric eyepieces bear the letter *E* in the name, such as *E-PL 10x/25 Br. foc*.

Both types of eyepieces are also available with combined properties. All of them are suitable for spectacle wearers, which is indicated by a *Br.* in the eyepiece's name. For these eyepieces, the optimal viewpoint is about 10 mm in front of the front lens, which makes it possible to keep the glasses on when the microscopic image is observed.

**NOTE**

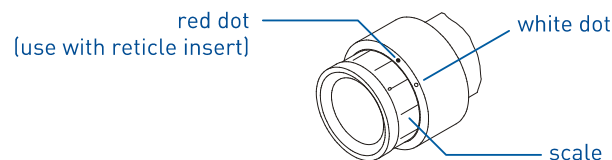
Users with glasses which have cylinder power should keep the glasses on when working with a microscope. The eyepieces can only compensate for spheric aberrations of the eye.

Furthermore, spectacle wearers who use the microscope without their glasses may experience unsatisfactory parfocalization after a change of objectives.

For all types of eyepieces, various types of crosshairs, graticules or scales are available. Contact a HSEB Sales representative, if a particular shape is needed. All kind of eyepiece insert will be seen sharply together with the sample surface. For that reason, mounting a reticle insert is a delicate work, that should be left to specialists because of the extreme requirements with regard to cleanliness.

For all types of eyepieces, rubber eyecups are available. They are used to exclude stray light and they serve as an aid to maintain the correct distance between the eye and the eyepieces.

eyepiece	P/N
eyepiece PL 10x/25 Br foc.	9444-03400
eyepiece E-PL 10x/25 Br. foc.	9444-23400
crossline graticule (d=26 mm, on glass plate)	9474-06400
eyepiece eyecup (rubber, 2 pc. required)	9444-80100



Axiotron 2 - Okular.pdf

figure 12 Eyepiece

The focusable eyepieces feature a scale and two dots, a red one and a white one. When using the microscope for the first time, the „zero“ mark of the scale should be brought into correspondence with the white dot (normally used) or the red dot (if the eyepiece is used with a crosshair reticle insert).

To adjust the eyepieces to individual vision, proceed as follows:

- Look into the eyepiece that is equipped with a crosshair and adjust the focal setting of this eyepiece, until the crosshair inside can be seen perfectly sharp. Do this with the eyepiece taken out, with the head put back and with a look to a distant view point (as to watch the horizon). This motion causes a reflex in the brain to relax the eyes and facilitates the process of accommodation to infinity.
- Then, using this eyepiece for viewing (but without changing it's setting), focus onto the specimen using the focus knob of the microscope. This will ensure that both the crosshair and the specimen can be seen sharply at the same time.

- Finally, while not touching the focus drive of the microscope, adjust the second eyepiece (by closing the eye on the side with the reticule, i.e. the one you just finished adjusting with) and adjust that eyepiece until the microscopic image is sharp.

Now, relaxed and sharp binocular vision is possible.

For „economy style“ eyepieces, no adjustment is possible with one of both. In that case, use this eyepiece first, look through it and focus onto the wafer. Then adjust the second eyepiece to your difference in vision.

**CAUTION**

Whenever possible, avoid to pull the eyepieces out of the binocular tube as to avoid particles to fall into the interior of the tube assembly. If the particles fall onto surfaces that are close to those giving a sharp image, the particles were visible in the field of view at all times. Time-consuming and, partially expensive cleaning procedures were necessary in that case.

Never keep the eyepieces taken out of the binocular tube. Their safest place (except for transport) is inside the tube.

4 WORKING WITH THE AXIOTRON 2

4.1 How To Find Focus

There are situations in which absolutely no image can be seen in the eyepieces and/or in the monitor. The most likely reason is, that probably somehow the microscope has run out of focus. Such a behaviour may occur if the autofocus is turned off and an objective is changed from a very low to a very high magnification. Since the depth of focus strongly depends on the magnification, a crisp image that can be seen with a 5x lens will not be visible in the 100x. Another reason might be a structure with a very high aspect ratio, which may „pull“ the laser autofocus out of the plane that is normally observed.

Below a simple method to get in focus is described. As a prerequisite, make sure that in the eyepieces or the monitor at least some intensity can be observed. This is important to distinguish between a „lost focus“ condition and a „no light“ condition, which requires a different approach to be resolved. For the latter case, refer to 'Known Faults And Their Recovery' on page 94.

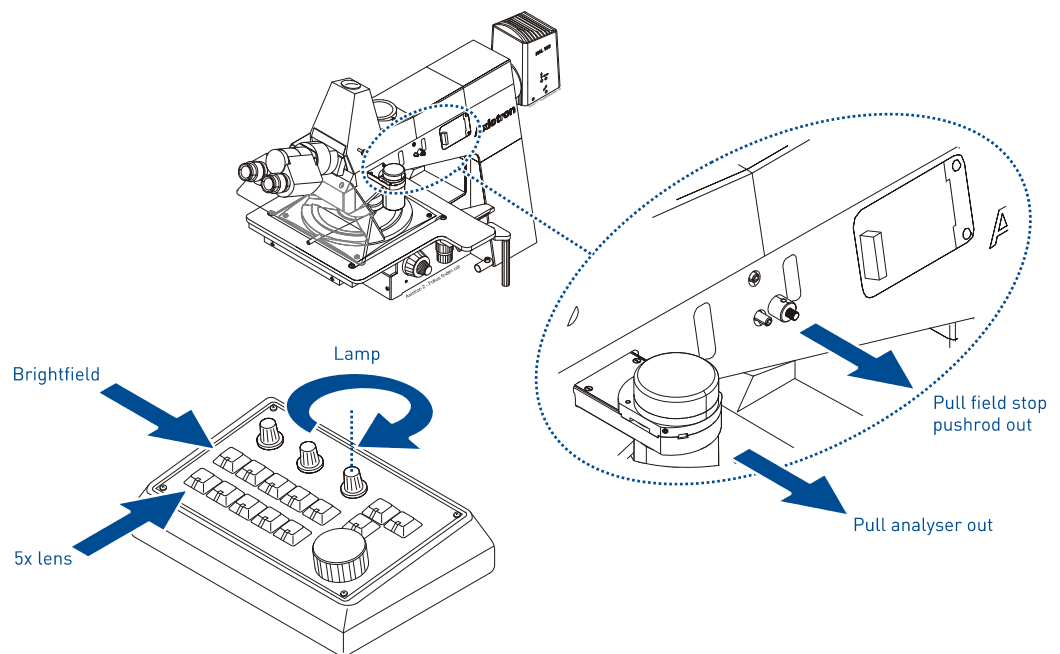


figure 13 Five actions that can help to find focus

- Make sure that a sample is loaded and that the microscope stage is at a position where the sample can be observed. This is a trivial prerequisite, but nevertheless worth a look.
- Switch the microscope to *Brightfield*.
- Switch to the lowest magnification, usually the *5x*.
- Pull out the *Analyser* slider.
- Turn the *Lamp* knob at the control panel to the right to get as much light intensity as possible.

- Close the field stop of the microscope by *pulling the push rod* (see figure 33 on page 57).
- The closed field stop will cause something like a keyhole view of the sample, i.e. the field of view is mainly dark, with the exception of a bright spot in the centre of the image. As the field stop is imaged sharply only if the sample is in focus, it can serve as an focussing aid as well, for samples with little or no structure in particular.

If this method does not lead to success, other possible reasons need to be taken into account, such as missing light from the light source, wrong slider positions or the use of thinner wafers, that cannot be observed, because the hard focus drive limit makes it impossible to focus onto it's surface.

A comprehensive guide on possible observation problems with the microscope can be found in 'Known Faults And Their Recovery' on page 94.

4.2 Magnification and Resolution

This chapter describes, what size of the specimen can be seen, if the user looks into the eyepieces or watches an image on the monitor.

The microscope is a composed optical system, which magnifies the details of the specimen in two stages. First a magnification of the specimen is done by the factor given by the objective. This is the so-called *intermediate image* which is then further magnified by the (built-in) tube lens and the eyepiece.

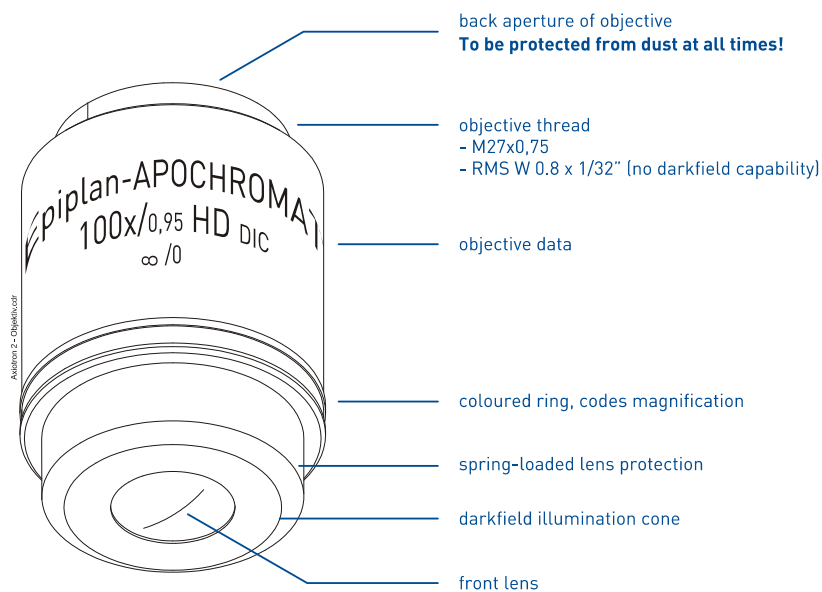
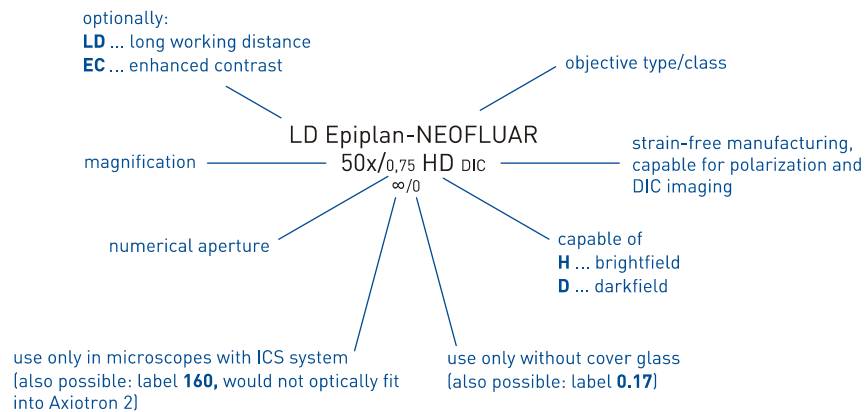


figure 14 Objective in detailed view

The overall magnification is given by the multiplication of the objective and eyepiece magnifications. As most eyepieces used with the Axiotron 2 do have a fixed magnification by a factor of 10x, the overall magnification is always ten times higher than the factor that can be read on the objective.



Axiotron 2 - Objektivdaten.pdf

figure 15 Explanation of objective data

The diameter of the intermediate image in the Axiotron 2 has been designed to 25 mm. With this information, the *field of view on the specimen* can be calculated by dividing the size of the intermediate image by the objective magnification factor. As an example, using a 50x objective, a circular area of $25 \text{ mm} / 50 = 500 \mu\text{m}$ can be observed.

NOTE

The usable field of view in the Axiotron 2 eyepiece is 25 mm. The camera port receives an intermediate image that is cut at the circumference, so that only 21 mm are available.

The diameter of the intermediate image plane in the CSM head is 16 mm.

The *resolution* is the amount of information obtained from the specimen. It strongly depends on the numerical aperture of the objective and on the contrast of the specimen. The higher the numerical aperture of the objective, the better the resolution becomes, that means, the closer two features on the specimen can be located and are still resolved. To calculate this resolution, a formula is used, that includes the wavelength used as well as the numerical aperture of the objective. If an electronic camera is used, that can enhance the contrast from the specimen better than the human eye does, and if a specimen with a good contrast ratio is used, the microscope resolution can be improved to a certain degree. The resolution limit is given with about 250 nm for brightfield and 180 nm with confocal scanning mode (CSM) in visible light, if an objective with a numerical aperture near one is used.

4.3 Camera-based Microscopy

4.3.1 Field of view

The *field of view in the camera* depends on the size of the camera chip. The name of a camera type (e.g. 2/3 inch) comes from the times when cameras were built as vacuum tubes. It described the outer diameter of this tube. The light-sensitive array in these cameras is always smaller than its name implies, however. A 2/3" camera mostly will have an effective diagonal chip size of 11 mm, which is approx. 0,44" and not 0,67".

In any case, today's CCD cameras have smaller optically sensitive fields of view than the size of the intermediate image plane, which means, that the image on the monitor in most cases will be a keyhole-like cutout from the eyepieces's field of view. The ratio of the cutout depends on the size of the CCD. If the ratio of the field of view between camera and eyepieces is a matter of concern, so-called zoom adapters may be used.

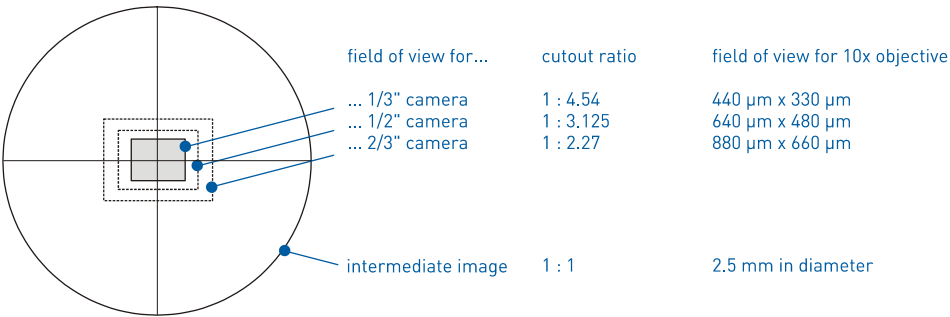


figure 16 Field of view in eyepiece and camera, depending on chip type, for a 10x objective

A variety of such adapters is available, such as with zoom factors of 0.63x, 0.5x and even 0.35x. The drawback of these adapters is a certain influence to the quality of the microscopic image with regard to vignetting and geometric distortion. Not every adapter will work with every camera size. Practical tests might be required before an installation can be carried out. For example, the combination of a 2/3" chip and a 0.5x adapter looks attractive, as it will allow an almost 1:1 ratio between eyepiece and camera, but the image will have dark corners, which is known as vignetting. Furthermore, 3-chip CCDs will show so-called colour-shading, which is an undesired interaction of the beams that form the intermediate image and colour separation optics inside the camera. For that reason, not all adapters are suitable for all chip sizes.

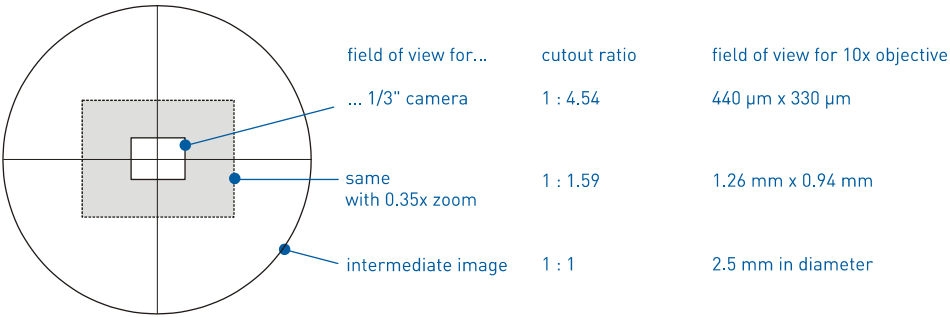


figure 17 Using a zoom adapter improves the cutout ratio.

A good solution for the Axiotron 2 is the 0.35x telecentric zoom adapter (9452-98900), which works well together with the standard cameras.

Another option is the usage of cameras with a bigger chip size, i.e. of sizes of up to one 1" (equals 16 mm diagonal). This method will yield best results, but is the most expensive way to expand the field of view, since such cameras are usually disproportionately expensive.

The third method might be the installation of a very low magnifying objective, such as of a 1.25x lens. The field of view of such an objective is approximately equal to a 5x objective seen through the eyepiece and might be a suitable solution especially for automated systems, but in general does not solve the issue of having a cutout effect in the camera image.

4.3.2 Resolution

A general drawback of a camera in comparison to the common eyepieces is the loss in resolution, especially at small magnifications. Whereas the human eye (through the eyepiece) may resolve up to 2.250 pixels for a 10x objective, for example, the same amount of optical information would be imaged with a PAL chip at 752 x 582 pixels and result in an disappointing loss of detail quality. An optical zoom smaller than 1:1 can turn out to be a general disadvantage for that reason, especially at lower magnifications. It would apply for any objective in the table below that indicates a higher required camera resolution than 752 x 582 pixels. The NTSC standard is not considered, as the relations in general are similar.

objective	visible line pairs in the entire (!) field of view	required camera resolution for 1/3" CCD chip
5x / 0,15	2.250	1.080 x 893
10x / 0,30	2.250	1.080 x 893
20x / 0,50	1.875	900 x 744
50x / 0,75	1.125	540 x 446
100x / 0,90	675	324 x 268

4.3.3 Magnification

In a conventional microscope using eyepieces, the magnification is given by the factors of objective and eyepiece magnifications, in other words, a 100x/0.9 objective and a 10x eyepiece will yield a overall magnification of $100 \times 10 = 1.000$ times magnification.

In a microscope using a camera/monitor combination, the calculation must be made in a different way, as the image that is observed by the user is always made up with the same amount of pixels, which is equal to the camera resolution. For a typical PAL camera, the resolution is, so far, always 752 x 582 pixels. These pixels are displayed on the monitor as an image of the same pixel number.

An - on the first glance - obvious way to calculate the magnification for such a microscope could be, to calculate the ratio between the observation area on the specimen and the size of the image on the monitor. Such a calculation, made for a 1/2" CCD with a 100x/0.90 objective and a zoom factor of 1.0x would give a sample region of $60 \mu\text{m} \times 50 \mu\text{m}$. The monitor image could be calculated using the number of camera pixels (which are displayed 1:1) and the common pixel size of a TFT monitor of 0.28 mm to $210 \times 163 \text{ mm}$. The ratio in this case is $210 \text{ mm} / 60 \mu\text{m} = 3.500\text{x}$. Is it true, that a camera-based microscope yields a much better resolution than a eyepiece-based one?

To understand the misconception of that calculation, it is helpful to determine the distance between observer and monitor, for which the resolution capability of the human eye exactly corresponds with the size of the monitor pixels. This assumption makes sense, because otherwise it would also be a possible method of gaining magnification by projecting the image to a size of a few metres in diagonal. However, the amount of true information, which the objective „delivers“, does not change if the image is blown up at the other end of the microscope.

The human eye can resolve details under a minimum angle of approximately one arc minute. For a convenient observation distance of 250 mm this resolution capability equals about 1/14 mm. To watch the TFT monitor under the same conditions, the observer needs to maintain a distance of approx. 875 mm to the screen. Vice versa, in the convenient observation distance of 250 mm the maximum required screen size is only about 55 mm x 36 mm. If now the ratio between field of view of specimen and monitor is calculated, the magnification is $55 \text{ mm} / 60 \mu\text{m} = 916$ times. This value corresponds well with the value for a eyepiece-based microscope.

4.4 Contrast Techniques

The following list gives an overview over the most common microscopy techniques that are appropriate for semiconductor inspection. This section is based on work that was contributed by [Andrew Ridley](#) of Carl Zeiss.

	BF VIS	DF	DIC	CSM VIS	365	248	Comments
Patterned Wafers							
discolourations	X						brightfield gives true colour, very useful for film thickness variations, implant variations, patterning errors at low magnification.
large particles	X						
macro defects	X	X		X	X	X	brightfield for low magnification, confocal or UV for pattern problems; darkfield for bubbles or scratches
collapsed pattern		X		X	X	X	highest magnification/resolution available
scratches		X	X				
buried scratches			X				scratches after thin film deposition and CMP usually can only be seen with DIC; low mag often works well.
CMP scratches embedded CMP particles		X	X				usually DIC works best as the scratches can be very thin, but long
small surface particles		X		X	X	X	
small buried particles	X	X		X	X		DUV does not view well through dielectric layers, 365 nm UV is better.
pattern extensions or notches				X	X	X	use highest magnification/resolution available
flakes of resist, dielectrics	X						colour helps to tell from which material is the particle

	BF VIS	DF	DIC	CSM VIS	365	248	Comments
Bare wafers							
sliplines (silicon dislocations after furnace)			X				best at low magnifications (5 or 10x), no other technique works
small particles	X				X	X	brightfield to get colour information, UV and DUV for resolution
scratches			X				
haze			X				For blanket layers deposited with roughness DIC at low mag is the most sensitive technique; often invisible in all other techniques.
Layers							
bare wafer	X	X	X		X	X	DIC, darkfield and UV most effective here
implant	X						discolourations due to uneven implant show best in brightfield
poly				X	X	X	high resolutions techniques for looking at pattern fidelity
contacts		X		X	X	X	missing contacts require die to die comparison to detect; 365 or 248 UV is best for mis-shaped contacts
dielectric	X		X	X			confocal is best to see interlayer defects, 365 is second best, brightfield third best
metal	X	X	X	X	X	X	If there is anti-reflective coating or oxide on metal lines then DUV is not as good as 365nm UV
via				X	X	X	confocal is best to see partially filled vias due to colour effect.
after CMP	X	X	X				dishing, filmthickness variation with brightfield, microscratches, abrasions, and small particles with DIC; large scratches and particles with darkfield
fully processed				X			confocal gives great contrast/resolution through thick dielectric. DUV is useless here.
back end layers			X	X	X		50x objective give 4.7 micron in focus simultaneously at high resolution; turn zoom up to max to get even higher mag. 100x gives 1.8 micron DOF which usually captures 2-3 layers. confocal very good for detecting shorts. DIC for metal grain.

4.4.1 Brightfield

Brightfield (*BF* or, German *H* for *Hellfeld*) is the most fundamental illumination technique used in reflected light microscopy. At the so-called reflector, light is directed via a 50:50 mirror towards the objective. The beam is projected on the surface of the specimen. The light from the specimen (containing image information) is reflected back through the objective lens, the reflector and towards the observer.

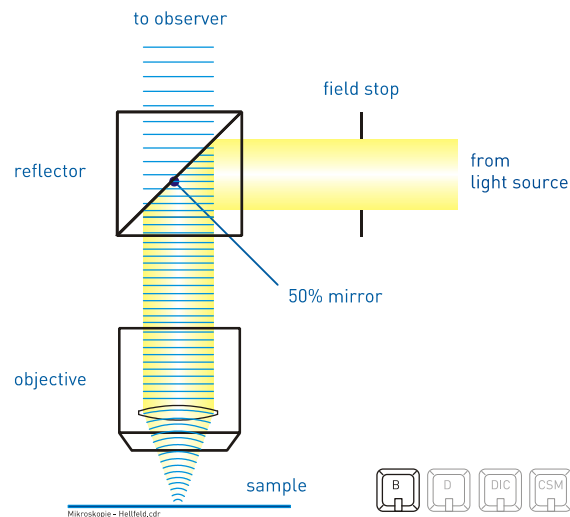


figure 18 The principle of brightfield imaging

Brightfield is the first choice to start an observation with. It is very easy to handle and it shows the topography of the sample. Brightfield can also be used in combination with additional software or hardware modules for film thickness, reflectivity, particle size and CD measurement.

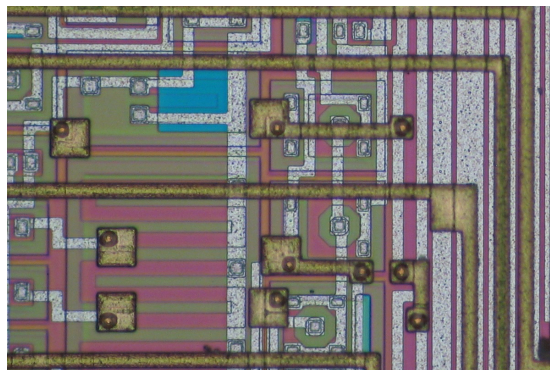


figure 19 Brightfield inspection (sample image)

4.4.2 Darkfield

Setting up a microscope for darkfield (DF) means to direct light onto the sample at an angle of incidence, under which any light, that is directly reflected by the sample, can not re-enter the objective. Technically this behaviour is achieved by a beam dump in the reflector cube, that blocks all illumination light at the centre, near the optical axis. Only a ring-shaped area at the periphery is illuminated. By means of a ring-shaped mirror in the reflector cube, this light ring is projected towards the sample. The objective features a secondary shell around the objective itself, that guides the illumination light and skims the light across the specimen. The angle of incidence for the illumination light is bigger than the numerical aperture of the objective. A surface that is ideally flat will appear totally dark for this reason. Structures on the sample as well as particles will generate stray light, however, that can be seen by the objective lens. This scattered light can be detected by the observer.

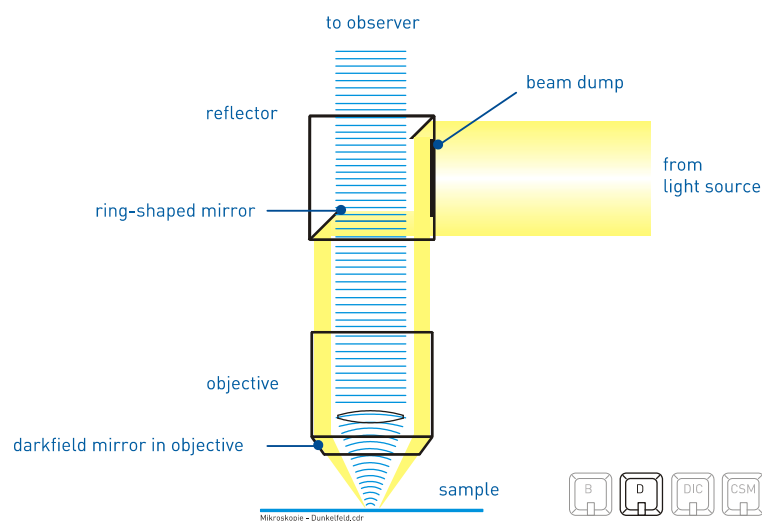


figure 20 The principle of darkfield imaging

Darkfield is a perfect illumination method for looking for very small defects, scratches or particles. Care is advised if darkfield is to be used for structure or particle measurements, because particles normally look bigger than they are. Take care that the light intensity is set to maximum and that the aperture and the field diaphragms are completely open.

The image below shows a brightfield and a darkfield image of the same sample. Particles and edges of structures appear clearly and bright.

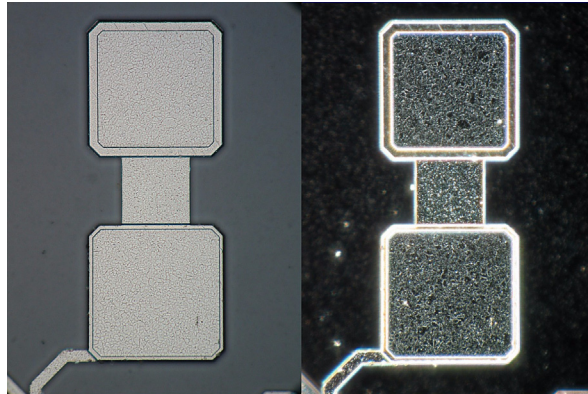


figure 21 Brightfield (left) in comparison to Darkfield inspection (right)

4.4.3 Differential Interference Contrast (DIC)

Differential Interference Contrast is used in situations in which a phase difference on the sample surface is to be observed. Phase differences occur at minute height differences of the sample surface or by changes of its refractive index. In brightfield these changes will remain invisible, since the amount of overall reflected light will not change much at those features. On the other hand, phase shifts cannot be seen with the naked eye. Hence, the idea behind DIC is to convert the phase differences into intensity differences.

The principle of DIC is as follows:

- The illumination beam passes a *polariser* where it becomes linearly polarised. By means of a 50% mirror (like in brightfield) it is reflected towards the sample.
- Before the illumination beam passes the objective, it passes a so-called *Wollaston* prism. The illumination beam is split into two coherent beams with a very small spatial separation.
- After passing the objective, the light reaches the sample. Upon reflection, tiny height differences and/or variations in the complex refractive index of the sample material will cause a *phase shift* between the two split beams.
- On the way back towards the observer, in the DIC prism the two split beams become unified. Since the two beams are coherent - as they were generated from the same light wave in the *Wollaston* prism before - after unification and passing the second polariser, the so-called *analyser*, they can interfere. Depending on the phase shift on the sample surface, amplification (constructive interference) or nullification (destructive interference) may take place.
- After passing the analyser, all light that was not affected by the interference effects is extinguished anyway (the illumination-side polariser and the observation-side analyser are crossed), so that - in principle - only the interference effects are visible. In the practical application of DIC the user will set the analyser to a position in which the image observed is brightfield with a DIC superposition.

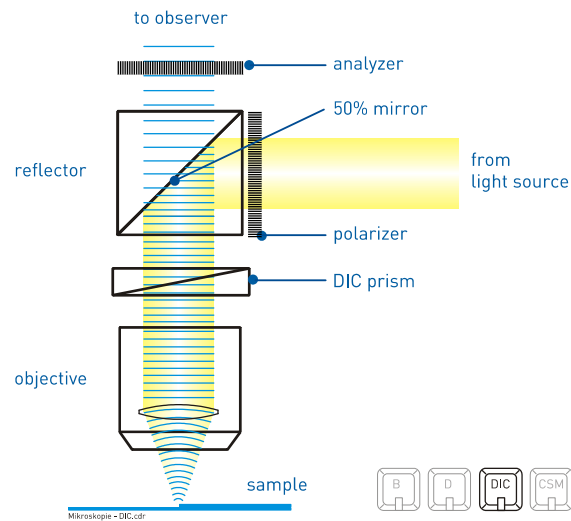


figure 22 The principle of differential interference contrast imaging

DIC is often used at visual inspections of metal layers or transparent "Poly" layers and photo resist film. DIC can also be very effective if very small particles are to be detected, and after etching procedures.

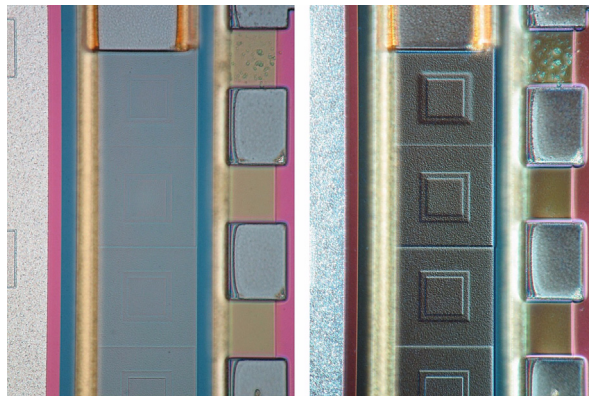


figure 23 Brightfield (left) in comparison to DIC inspection (right)

Note, that the presence of a DIC prism always splits the illumination light in two beams. Using the prisms in bright field may result in double images on critical structures. The image below was taken using an old-style +DIC slider. The area depicted has been cut out and re-magnified.

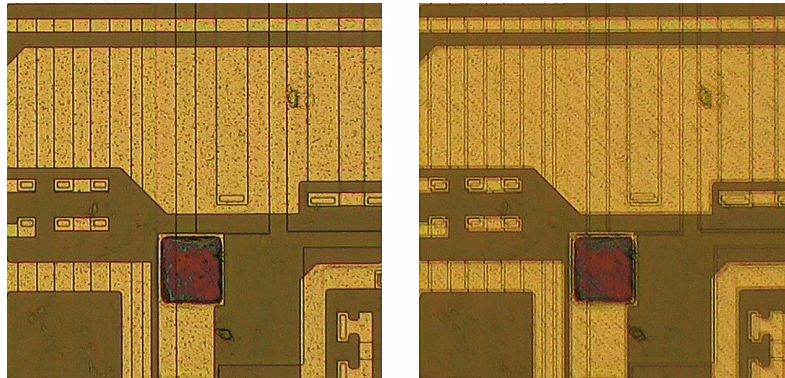


figure 24 Double image at critical structures in DIC

Also keep in mind, that the three-dimensional effect of DIC does not mean, that DIC produces a 3D image indeed. This can easily be clarified by moving the polariser to positions symmetric to the position of darkest DIC contrast. Structures appearing elevated before will turn hollow.

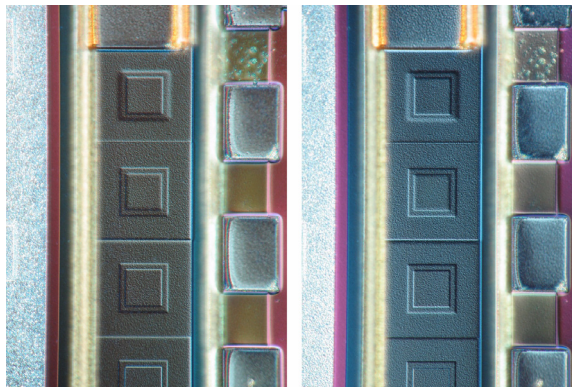


figure 25 DIC is not a 3D imaging principle. Both images were obtained by analyser rotation only.

4.4.4 Confocal Scanning Mode (CSM)

In brightfield, scattered light that emerges from above and below the focal plane has a negative impact on the theoretical resolution of the objective and also on the achievable contrast. Furthermore, the depth of focus of an objective is the smaller, the higher the numerical aperture (*NA*) of an objective gets. This is a major drawback, since a high numerical aperture is always desired for a high spatial resolution, i.e. the detection of fine sample details. To overcome these disadvantages, the CSM principle has been developed.

The main component is a spinning disk with 70.000 pinholes. After the inventor of this disk, that was used for the proof-of-concept of the first television in the 1930s, the disk is also called "Nipkow disk". For each of its pinholes, light from the specimen can only pass if the so-called "confocal condition" is fulfilled. The Nipkow disk is located at an intermediate plane that is conjugated to the sample plane of the objective, i.e. the focus plane of the objective is precisely projected into the plane where the Nipkow disk is located.

For a given pinhole position on the disk, there is exactly one point $[x, y, z]$ at the sample, from which reflected light can pass the pinhole. Light from adjacent sample regions does not fulfil this condition, cannot pass and is cut off. As the disk rotates, this confocal condition is, for a given period of time, fulfilled for each sample point $[x, y]$ in the field of view of the objective, which, for the disk is rotating fast enough, yields a live image of a precisely defined z level of the sample.

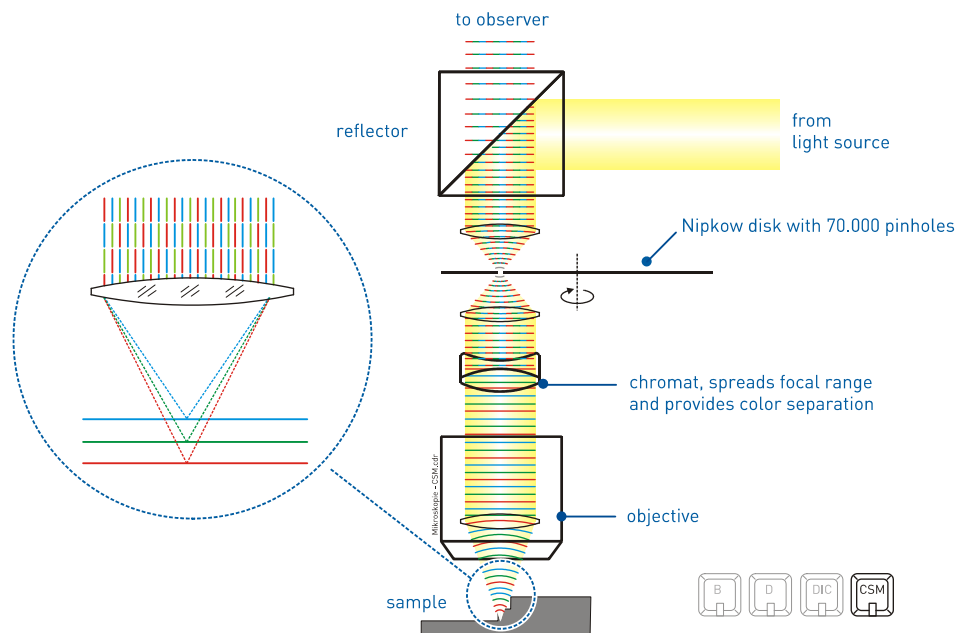


figure 26 The principle of confocal scanned imaging

A particular advantage of the Zeiss-CSM, that is used in the Axiotron 2, is a patented optical component *Chromat C*, that introduces a precisely defined colour aberration into the optical system. As a result, the described confocal condition (= point-to-point imaging) is fulfilled for each of the colours of the spectrum at a different z level. This measure drastically increases the depth of focus for the optics, because in common brightfield the image is only crisp, if the focal plane is the same for all colours. As a side-effect, in CSM mode the sample is imaged in a false-colour scheme, each colour representing a different z level. Colours with longer wavelengths (i.e. red) are bottom layers, colours with shorter wavelengths (blue) are top layers, with the complete visible spectrum in its order inbetween.

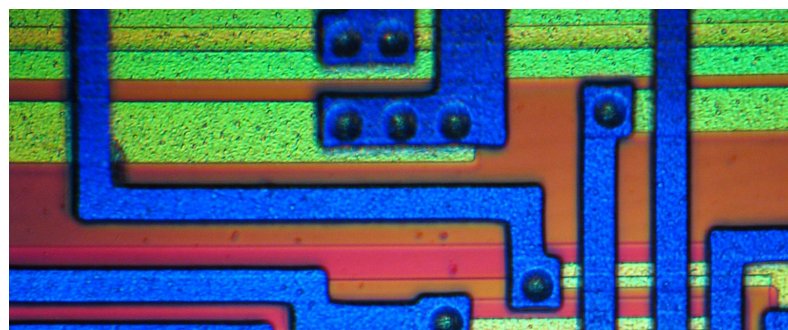


figure 27 A characteristics of the CSM mode is the colour separation by sample height

In the table below some average values for the range can be found, that represent the extended depth of focus by splitting the colour range between red and blue. The reference values in the *BF* column show an estimation of the focal depth in the eyepieces in Brightfield by using the formula according to *BEREK*.

objective	CSM	BF
EC Epiplan Neofluar 5x/0,13	470	68
EC Epiplan Neofluar 10x/0,3	100	14
EC Epiplan Apochromat 20x/0,5	30	4,5
EC Epiplan Apochromat 50x / 0,95	4	1
EC Epiplan Apochromat 100x/0,95	1	0,7

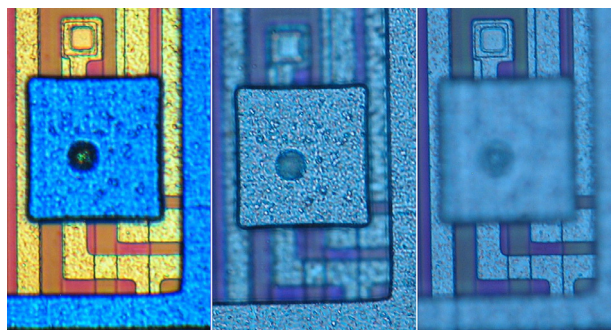


figure 28 CSM inspection (left), in comparison to Brightfield shows the extended depth of focus

When the microscope is taught for CSM mode, always take care that the light intensity is set to maximum and that the aperture and the field diaphragms are completely open. Set the aperture to a slightly lower diameter if a blue haze in the lower part of the eyepiece image should be observed.

The full colour range can only be achieved by using objectives of the *Apochromat* line.

4.4.5 Ultraviolet (UV)

The wave-characteristics of light causes diffractions at any given sample structure or optical component. If the size of the sample structures become so small, that they reach into the wavelength range of the light that is used to observe them, diffraction effects will emerge and, from a certain point on, will make imaging impossible. The basic formula to estimate the resolution limit is the criterion by Abbe as shown below.

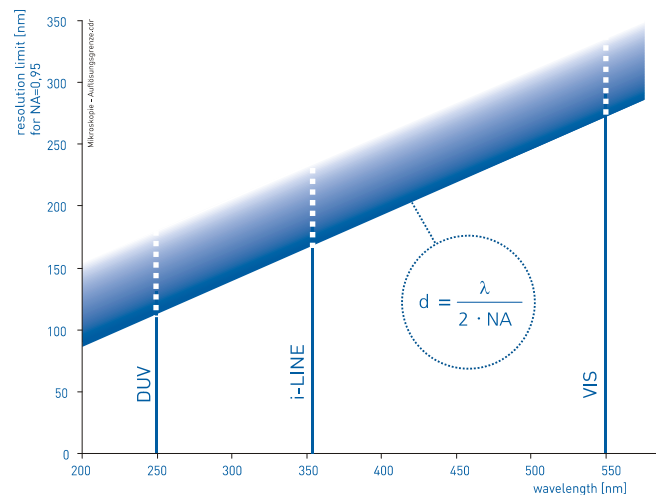


figure 29 The precise resolution limit strongly depends on sample properties like contrast and reflectance and can only be estimated.

A simple comparison between the theoretical resolutions for 248 nm, 365 nm and visible light with about 550 nm (green) shows the gain in resolution. A numerical aperture of 0,95 is the practical limit for dry objectives. In figure 29 the differences in resolution is shown, if ultraviolet light is used, compared to "normal" light in the visible range of the spectrum.

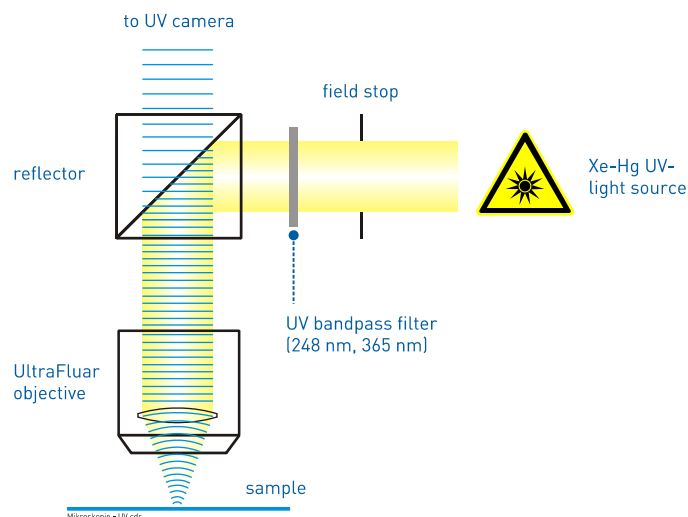


figure 30 The principle of brightfield imaging using ultraviolet light

The *limit of resolution* depends on the minimum contrast (= intensity difference) between two features and the space between, and is also different for lateral and focal direction. In other words, the formula given above starts from a set of assumptions that are not to be discussed here. Statements like "DUV can resolve 90 nm" is to be handled with care for the same reason, especially if the conditions are not known. For an estimation of the gain of performance it is sufficient, however. As the human eye is not able to see light below 400 nm, a dedicated, UV-sensitive camera is used for this purpose. A high-pressure Mercury/Xenon lamp is used to generate the short-wavelength radiation required.

In general, ultraviolet imaging is very similar to brightfield. In figure 30 the beam path for UV imaging is shown, which - beside a band pass filter and some UV-specific components, such as quartz optics and special coatings - is very alike to brightfield in the visible range of the spectrum.

UV can best be used for small metal structures. The user should be aware, that the high energy of the short wavelengths may alter photo resist structures. Also the ultraviolet light is absorbed by certain materials, so that an UV image might be remarkably darker than a conventional bright field image.

4.4.6 Confocal imaging with i-line (CSM UV)

The basic principle and the benefits of the use of ultraviolet over visible light and those of the confocal mode over plain brightfield imaging have been explained in the previous chapters and are not to be repeated here. For the confocal mode with ultraviolet light, some specifics need to be pointed out, however.

The main difference is the fact, that both the light source emission as well as the transmission characteristics of the dedicated i-line objectives is very narrow, typically some five nanometres. This means, the benefit of a CSM VIS, which is to extend the focal depth because of the artificially introduced chromatic aberration of the objectives does not apply for i-line CSM imaging. As a result, the depth of focus is very narrow, even narrower as for the brightfield UV mode. However, this behaviour is, nevertheless, beneficial for high-resolution imaging.

The second advantage of confocal imaging, which is the extinction of stray light that is generated beyond the focal plane and adjacent from the point of interest, will still take effect and contribute to a high-contrast image, which cannot be obtained using conventional brightfield imaging.

A side effect of this principle is the strong susceptibility of the microscope to environmental vibrations, that might cause the image to flicker, since even changes of the distance between the objective and the microscope body of a few ten nanometres will drag the image out of the plane where it can be transmitted. Hence, the use of anti-vibration assemblies, such as actively damped microscope tables, is strongly recommended. The Axiotron 2 features such an actively damped microscope suspension.

4.4.7 Fluorescence

The setup of the microscope for Fluorescence microscopy (FL) is quite similar to bright-field. The difference lies again in the setup of the reflector cube, which contains two colour filters and one so-called dichroic (colour-separating) mirror.

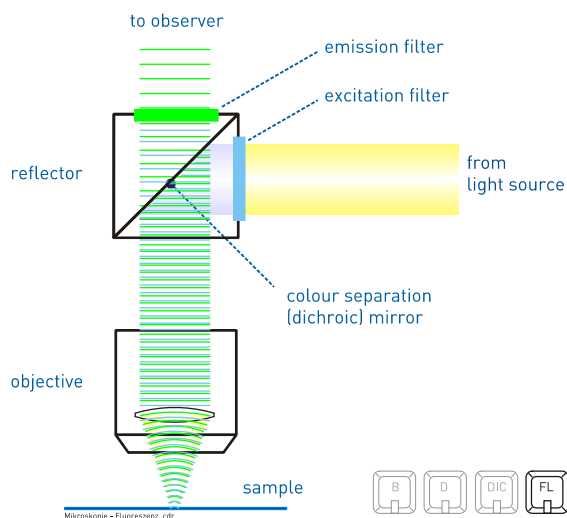


figure 31 The principle of fluorescence imaging

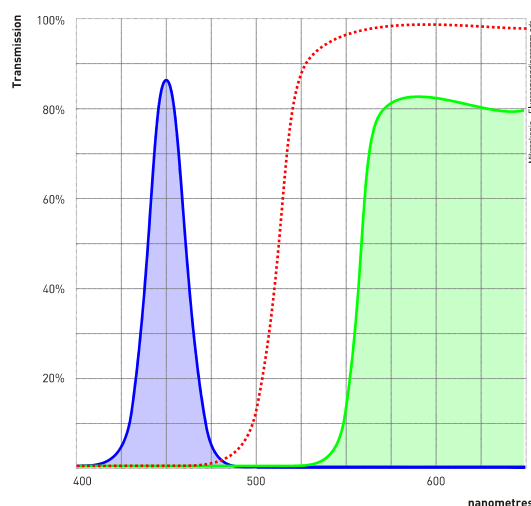
Without stressing the physical background too much, the basic principle is to excite a material by exposing it to light of a certain wavelength. Atoms or molecules are excited, which means, that their electrons are elevated to higher energy levels. After being excited, they immediately relax and cause a photon to be emitted. A certain amount of energy is „wasted“ in this process, so that the energy of the emitted photon is lower than the energy of the photon that was required to excite the molecule. According to the formula $E=h\nu$, the wavelength is the higher, the smaller the involved energy is.

The energy difference between excitation and emission equals a wavelength difference, the so-called *Stokes* shift, which is usually something between 50 and 100 nanometres. This wavelength difference is roundabout the „distance“ between blue and green or green and red light. Fluorescence can so far be quickly summarized for example by: *blue light in / green light out*, or *green light in / red light out*.

To detect fluorescence, it is necessary to separate the excitation from the emission. The intensity ratio is quite small, so that a weak emission could not be detected at all, if the excitation light were not completely cut off in the emission beam path. For that reason, the optical setup comprises three elements:

- The *excitation filter* cuts out a narrow band from the available light spectrum, that is dimensioned to exactly match the wavelength (i.e. the energy) that is required to excite the target molecules. No other light is required to initiate the fluorescence effect, so that it can be cut off.
- The *emission filter* does not transmit any light in the wavelength range where the excitation takes place. Behind the emission filter, the image is dark for that reason: the emission energy cannot protrude, for that reason no classical brightfield or darkfield imaging is possible. The only visible light would then be caused by the emission of the fluorescent material.

- As both the excitation and the emission filter are not ideal components with zero transmission at the critical wavelengths (where the capability to block the adverse wavelength is essential), a *dichroic mirror* is added. This mirror exhibits a wavelength-sensitive reflectivity and contributes to the wavelength selection of both the excitation and the emission range.



The dichroic mirror does not transmit any excitation light, but as energy cannot be "consumed", by neglecting absorbance, 0% transmission mean 100% reflection. For emission, the relations are reverse.

The excitation filter allows only a narrow band of the available illumination to pass

The emission filter opens far from the range of excitation.

figure 32 The principle of three-step wavelength separation in fluorescence

Below the combinations of excitation filter, dichroic mirror and emission filter are listed, that are of highest relevance to semiconductor applications. The nomenclature of the optics components describes the wavelengths, the bandwidth and the filter characteristics. For example,

- a *BP 450-490* is a band pass, that „opens“ between 450 and 490 nm; *BP 365/12* is a band pass with 365 nm plus/minus 12 nm bandwidth (FWHM). The excitation filter in figure 32 is a band pass
- a *LP 520* is a long pass, that opens at 520 nm and remains „open“ for longer wavelengths. The emission filter in figure 32 is a long pass.
- a *FT 470* (german: *FT* for Farbteiler) is a chromatic beam splitter with a centre wavelength of 470 nm

set name	P/N	excitation	dichroic	emission
01	9488-00100	BP365/12	FT395	LP397
02	9487-90200	G365	FT395	LP420
05	9488-00500	BP395-440	FT460	LP470
06	9487-90600	BP436/10	FT460	LP470
09	9487-90900	BP450-490	FT510	LP520
14	9487-91400	BP510-560	FT580	LP590
15	9487-91500	BP546/12	FT580	LP590

The use of the filter sets depending on the application is as follows:

application	filter set number
organic contaminants	02, 06, 14, 15
negative photo resist	09
positive photo resist	14
photo resist contaminants	05

For best results, it is required to select the light source depending on the excitation wavelengths. Filter sets like *01*, which employ a *BP365/12* as excitation filter also require a light source that is capable to deliver sufficient intensity in the range of 365 nm. For such an application, a HBO103 mercury lamp is the best choice. For other filter sets, like *06*, *09*, *14*, *15* also a HAL100 also would do, but it's intensity still may not be sufficient. A XBO75 or a LG Xe 180W remote will have sufficient intensity. Arc lamps are usually the best choice for fluorescence application.



NOTE

For fluorescence applications, it is beneficial to use objectives with the highest numerical aperture available, as the capability to collect light depends on the square of the numerical aperture of the objective. Usually this condition is best fulfilled with the EC Epiplan Apochromat line.

5 MAINTENANCE AND SERVICE

5.1 Microscope Adjustment (Köhler Illumination)

The so-called Köhler Illumination is a procedure to correctly setup a microscope for optimum performance. It is named after August Köhler (1866-1948), who is said to be one of the inventors of the modern optical microscope. In 1893 Köhler published a method of microscope illumination, that still bears his name. The idea of two sets of conjugated planes produces an evenly illuminated field of view and a brighter image without obscuring glare.

Below two identical procedures can be found. The first one is very brief and serves as a mental note for experienced users, the second procedure has the same content, but is more detailed.

5.1.1 Köhler Illumination for Power-User

- Align illuminator (refer to "Illuminators" on page 74ff.)
- Enter teach mode @ 100x Brightfield (or the highest magnification available for visible light)
- Use auxiliary microscope or pull one eyepiece out
 - aperture diaphragm must be crisp and centric relative to objective's pupil
 - set aperture diameter to 60...80% of objective's pupil
- Remove diffuser
 - HAL100 lamp filament must be crisp
 - put diffuser back in beam path
- Use eyepieces
 - set field stop to 101%
 - adjust convenient brightness; mind presence of analyser and yellow filter
 - store settings
- Repeat these steps for all objectives, except the centring and Z shift of the aperture diaphragm.

5.1.2 Köhler Illumination For Beginners

- Switch the microscope on.
- For use with HAL100, align it as described in "Halogen Lamp HAL100" on page 74. The high-power xenon light generator does not need to be aligned.
- Put an even, well-reflecting specimen, like a blank wafer, onto the stage.
- Use brightfield mode and select an objective with a low magnification.
- Pull on the pushrod for the field stop to set it to a small diameter.
 - Use this partially closed field stop to find the focal plane.
 - As the field stop is located at a place that is imaged sharply at the same time as the specimen, the focal plane (i.e. the level at which the image is sharp) is reached when the field stop is visible. This is important, if the wafer is too clean and does not have any features, like particles or scratches on it.
- Start with a low magnifying objective, refocus and gradually increase magnification, until the objective with the highest magnification is in the beam path and the image is sharp.

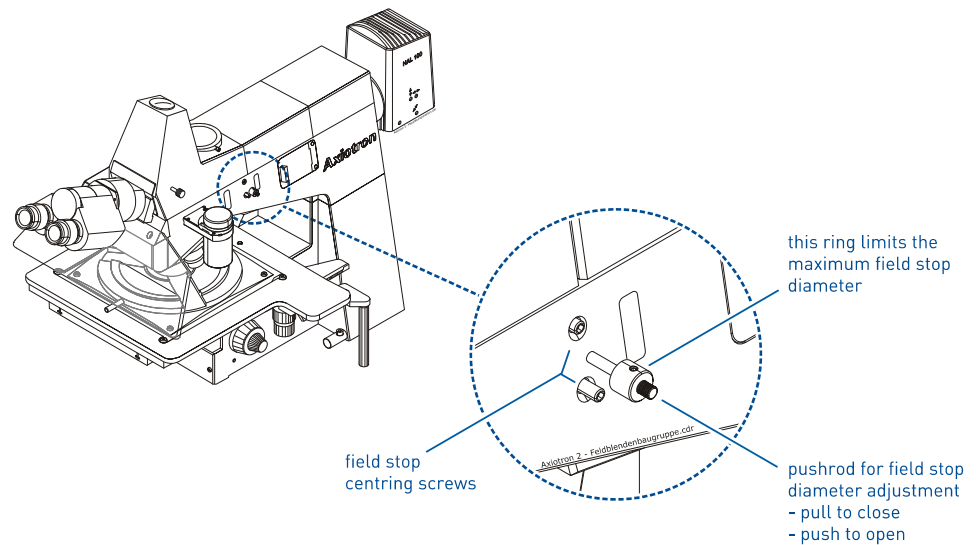


figure 33 Components for the alignment of the field stop

- Remove one eyepiece and replace it by an auxiliary microscope (see “Spare Parts” on page 99), or look directly into the empty eyepiece aperture.
- With the control panel, go to teach mode by pressing the objective or reflector button together with the **AUX** key for a couple of seconds.
 - The teach mode is activated and indicated by a blinking **AUX** LED.



NOTE

When entering the teach mode, be careful not to lose mains power supply. In case of a mains voltage breakdown, unintended triggering of the **Emergency Off** switch or other events that cause the mains power of the microscope to disappear, all microscope presets are invalidated. In this case the microscope parameters need to be restored from the computer backup using the service software.

- Adjust the lamp to maximum by turning the lamp potentiometer on the control panel to the right.
- Open the aperture to full diameter by turning the aperture knob on the control panel to the right.
- In the auxiliary microscope, a diffuse bright spot in the middle of the field of view can be seen. Focus on the objective's pupil by shifting the inner tube of the auxiliary microscope back and forth. Fix the position of the auxiliary microscope by means of its set screw if the objective's pupil can be seen sharply.
- If there is no auxiliary microscope available, the same effect can be achieved by looking into the empty eyepiece aperture. While this method is applicable at lower magnifications, it is difficult to see the necessary details on higher magnifications. So far, the use of an auxiliary microscope is recommended.
- In general, at this stage of the alignment a bright circle within a black area can be seen. The edge of the bright circle is clearly visible and sharp.

- By turning the aperture knob to the left, the aperture diaphragm is closed a little, until the polygonal shape of the diaphragm appears. This shape is probably not imaged sharply.
- Unclamp the focus mechanism for the aperture diaphragm assembly, which is located behind the door on the right-hand side of the upper stand part. The screw is shown under **1** in figure 33.
- By shifting the entire aperture assembly back and forth using the focus adjustment screw (**2** in figure 33), the aperture diaphragm is brought in focus, as good as it is possible.
- The aperture diaphragm is now in focus, as well as the objective's pupil. This means, in the eyepiece aperture or in the auxiliary microscope two concentric circles can be seen; a round one with a bigger diameter and a polygonal with a slightly smaller diameter. Both are sharply visible.

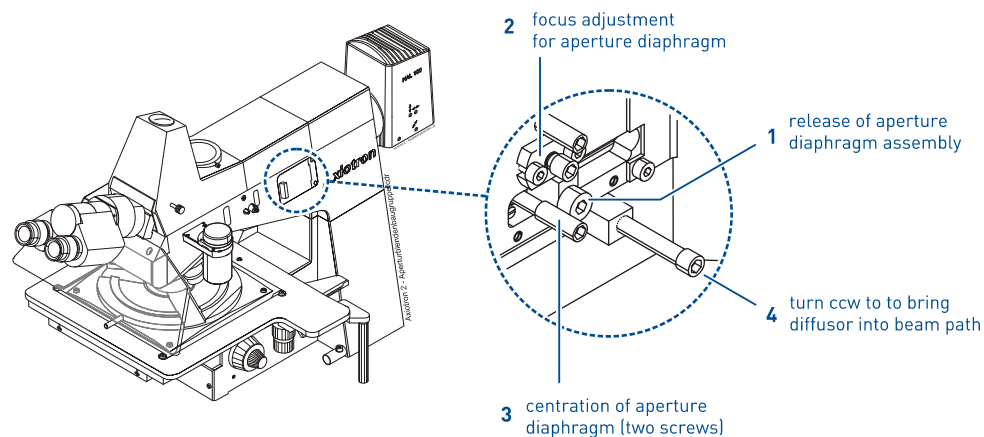


figure 34 Adjustment screws for the alignment of the aperture diaphragm

- By adjusting the centring screws (**3** in figure 33), the aperture diaphragm is brought to a position concentric to the objective's pupil. It might be required to adjust the diameter of the aperture diaphragm during this step, if it is not small enough to be seen clearly.
- When using an auxiliary microscope, do not adjust the aperture position relative to the crosshair of the auxiliary microscope, do it only concentric to the objective's pupil.
- By adjusting the aperture potentiometer on the control panel, set the diameter of the aperture diaphragm to 60...80% of the diameter of the pupil.
 - When using a HAL100 lamp for illumination, move the diffusor on the aperture assembly out of the beam path by turning it's allen screw clockwise (**4** in figure 33).
 - Move the collector of the halogen lamp back and forth, until the crisp image of the lamp filament in the auxiliary microscope can be seen.
 - Move the diffusor on the aperture assembly (**4** in figure 33) back into the beam path by turning anti-clockwise.
- Replace the auxiliary microscope by the common eyepiece.
- Refocus onto the specimen, as the focus may have changed accidentally.

- Adjust for convenient illumination using the lamp knob, then store the current settings by pressing the [AUX](#) button.
- Pull on the pushrod for the field stop to close the field stop slightly.
- As the field stop may be de-centred, check and, if necessary, adjust it by means of the centring screws on the right side of the microscope (for details see "Components for the alignment of the field stop" on page 57).
- If it is clear, that the field stop is centred correctly, open it to a diameter that is slightly bigger than the field of view (so to say, 101%). Place the ring (that has been removed before) back onto the pushrod and tighten the set screw so that the field stop cannot be opened any further as set by now.
- If the observation of the specimen is always done with a camera and never with the eyepieces, the field stop diameter may be further decreased, so that the camera image is just not yet cut off in the corners. This setting will contribute to a better stray light behaviour of the microscope, especially for fluorescence applications, but will limit the illuminated area that is visible in the eyepieces.

**NOTE**

For a basic understanding of the adjustment principle, two groups of optical planes and terms must be clearly distinguished, which are „conjugated“, i.e. which are always visible sharp at the same time. These two planes are named „field planes“ and „pupil planes“.

Field planes can be looked at using the eyepiece. The following locations are conjugated to the field plane: specimen, intermediate image, eyepiece crosshair, field stop, camera image.

Pupil planes can only be looked at using no eyepiece or an auxiliary microscope. The following locations are conjugated to the pupil plane: objective pupil, aperture diameter, lamp filament.

5.2 Köhler Illumination in Transmitted Light

To adjust Köhler illumination in transmitted light, it is important to understand, that there is one significant difference between reflected light and transmitted light microscopy: in reflected light, the field stop is automatically conjugated to the image plane, in transmitted light it is not. This means, with a non-adjusted microscope, in transmitted light it is possible either to focus on the sample [or](#) on the field stop if the focus drive is moved. Hence, before the Köhler illumination can be adjusted, it is necessary to find the focal plane.

In general, to find the focal plane in transmitted light it is possible to use reflected light first. The principle to get in focus is described in 'How To Find Focus' on page 37. This is preferably done with the lowest magnification possible. Once the focal plane has been found, the adjustment of Köhler illumination can begin.

**NOTE**

As in transmitted light the objective cannot serve as condensor as in reflected light, fine adjustments of the correct condensor position and field stop diameter may become necessary after every change of an objective.

- Stay with the *smallest magnification possible*, do not touch the focus drive during the procedure.
- Switch the microscope to *darkfield*. As explained in figure 20 on page 45, the observation beam path of a darkfield reflector cube is just empty.
- Switch the *transmitted light illuminator* on. Before doing so, check that the intensity of the lamp is set to minimum. Looking into a 100 watts halogen lamp with the eye may cause irritation or even injury.
- *Close the field stop* (3 in figure 35) by rotating the plastic ring clockwise

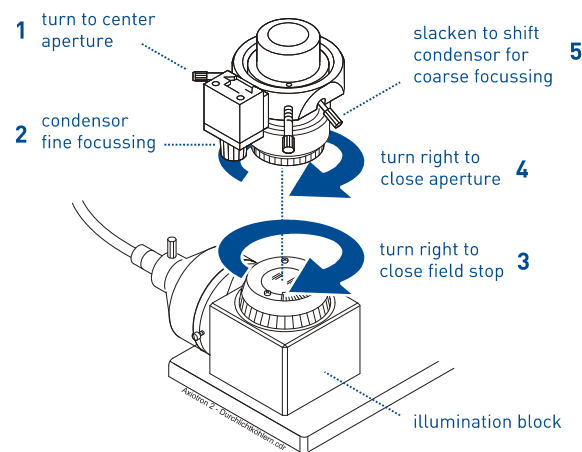


figure 35 Components that are involved in transmitted-light Köhler illumination

- In the eyepieces, a dimly lit circle should be visible. This is the back-illuminated field stop for transmitted light, which is located in the square illuminator block shown in figure 35. If it is not visible, gradually increase the light intensity. If still nothing can be seen, check if there is an opaque sample on the stage that blocks the light. Also check that the eyepieces are activated (which may be an issue if a CSM is installed).
- By turning the knurled screw of the condensor holder (2 in figure 35), move it up and down and try to adjust a sharp image of the field stop. If the focussing range is not sufficient, set the fine focussing screw to about half the travelling range, slacken the set screw (5 in figure 35), shift the entire condensor assembly and bring it (almost) in focus. Fine-adjustment is done with the focussing screws afterwards. When shifting the condensor, avoid to touch the sample stage insert or the sample itself with the condensor optics from below.



NOTE

A rough condensor focus alignment is usually only necessary if a new sample stage or a total new type of sample is to be observed for the first time.

- Using the centring screws (1 in figure 35), bring the field stop to a position which is concentric to the eyepiece's field of view.
- Set the diameter of the field stop to match the eyepiece's field of view.

- With the aperture ring (4 in figure 35), a good trade-off between image contrast and resolution can be achieved.

**CAUTION**

For infrared applications, high illumination intensity can *damage plastic sample holders or samples*, if they exhibit a high absorbance in the wavelength range that is used for imaging.

5.2.1 Notes On Microscope Illumination Defaults

When the default settings are defined, it is important to know, in which configuration the microscope will be used most of the time. Several components can be brought in or out of the beam path, which all have an influence to the overall intensity in the camera and the colour temperature of the resulting image. While the eye can accommodate to different intensities and tints quite easy, the camera - especially if it cannot be set to automatic gain control - will be continuously be over- or underexposed if the necessary prerequisites are not observed, or the image will appear yellowish or blueish.

- **Analyser**
 - The analyser is, technically spoken, a polarising filter. For unpolarised light, such as it is used in brightfield or darkfield, it blocks 50% intensity.
 - The decision to be made is, whether it shall be inserted in the beam path at all times or not. While it is strongly recommended to take it out for darkfield observation, the analyser may be kept in the beam path for brightfield. This will also reduce the effect of double images that sometimes can be observed on critical structures, especially with the „high contrast“ DIC sliders.
 - The analyser has the effect of a slightly blueish colour filter.
- **Yellow Filter**
 - The yellow filter is required for application in photolithography areas. So far, there is not really a degree of freedom, whether to keep it in or out.
 - For setting of the white balance function of the camera, the yellow filter must be in it's final position.
- **Eyepiece/Camera slider on binocular tube.**
 - This slider provides a 80/20 or 100/0 intensity split between camera and eyepieces. As the amount of light towards the camera will change if the slider is moved, it is also important to define the slider position before intensity defaults are stored.
 - The slider may be carefully unscrewed and stored if the default setting has been defined. This helps to avoid complaints by operators who have accidentally changed the slider position and who now have a constant over- or underexposure of the camera image.

If these three optical elements are set to defined positions and if the position is kept during setup and also later during operation, the defined settings will be sufficiently reproducible.

5.2.2 Microscope Settings and Imaging Modes

For *brightfield illumination*, Köhler Illumination is very essential. The diameter of the aperture diaphragm should be at about 60...80% of the pupil diameter.

For *darkfield illumination*, the Köhler principle does not apply. Here an off-centred illumination beam is skimmed across the wafer surface, so that any particles or smaller features generate stray light. This is the idea of darkfield. The angle of illumination is defined by the angle of the illumination cone in the objective and does not change for a given objective. So far, closing the aperture diaphragm will only cause a decreased intensity, but it will not improve image quality.

For *DIC*, in general the same considerations as for brightfield apply. As the principle of DIC involves the usage of a glass prism with birefringent properties, light from the sample is split up into two different beam portions, that are imaged at the same time. This means to artificially decrease the optical resolution limit (the observer sees a double image), by gaining better capability of the detection of minute height variations. For that reason, the trade-off between resolution and contrast can be liberally optimized towards best contrast conditions, which means in turn, that the aperture diameter may be set to 50% or less of the objective's pupil diameter. Details on DIC adjustment can be found in "Setup Of Differential Interference Contrast" on page 63ff.

For *CSM* mode, the aperture should generally be at 100%, since the limitation of illuminates area is given by the projection of the pinhole in the Nipkow disk. However, due to the design of the CSM, stray light will cover the entire field of view. The aperture diaphragm must be closed until the stray light has disappeared, regardless of the pupil diameter of the objective. This will slightly affect resolution, but in fact it is more than compensated by the higher degree of detail that is visible after the stray light has been cut off.

In *Fluorescence*, the aperture diameter must be fully opened. It is necessary to get as much light into the sample as possible. The diffusor disk in the illumination beam path should be swivelled out. The analyser must be pulled out, as it would absorb 50% intensity otherwise. Arc lamps with appropriate spectrum are the preferable light source. Under fluorescence, the emitted intensity is sometime so small, that undesired reflexes (such as from the camera chip) or ceiling illumination (via the eyepieces) become visible in the camera image.

5.3 Setup Of Differential Interference Contrast

5.3.1 Differential Interference Contrast for Power Users

Step 1

- DIC slider out
- eyepiece out
- auxiliary microscope in
- analyser in
- teach mode on
- adjust analyser until extinction cross is visible or the field of view in the binocular tube is completely dark.

Step 2

- DIC in
- auxiliary microscope out
- eyepiece in
- adjust DIC slider position until broad dark strip crosses field of view or until the image in the eyepiece is completely dark.

Step 3

- adjust analyser until optimum DIC contrast is achieved. If two equivalent settings left and right of the darkest position can be set, select the one with the analyser knob turned more to the right.
- close aperture diaphragm to 20...50% of the numerical aperture of the objective.
- re-adjust brightness.
- confirm teach mode and store settings.

5.3.2 Differential Interference Contrast For Beginners

To locate the parts involved in the DIC mode, refer to figure 36 below.

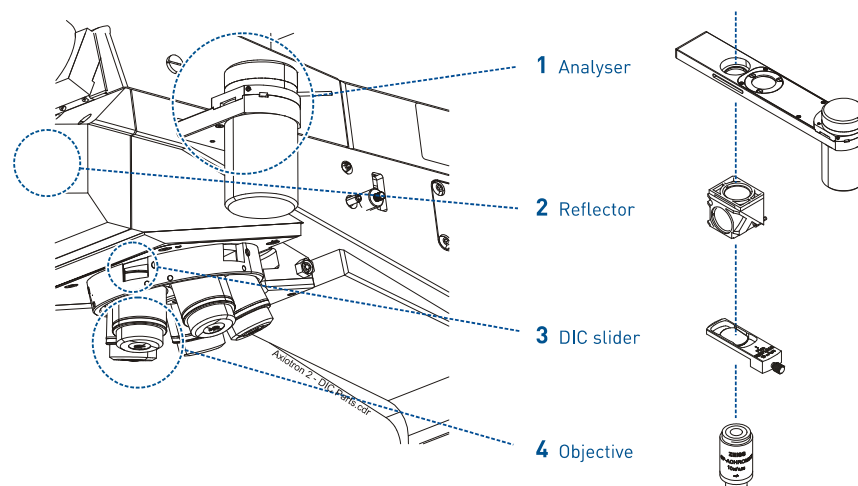


figure 36 Location of components used for DIC

- Pull out all DIC sliders.
- Check that all DIC sliders are the correct ones for each objective, respectively. Mostly the engraving on the DIC slider is the same as on the objective (especially for older objectives), but it is also possible that one DIC slider fits more than one objective. A table with the most common objectives and appropriate DIC sliders can be found below.

objective	cat. no. of DIC slider
EC Epiplan Neofluar 5x / 0,13 EC Epiplan Neofluar 10x / 0,25 EC Epiplan Neofluar 20x / 0,50 EC Epiplan Apochromat 10x / 0,30 EC Epiplan Apochromat 20x / 0,60	9011-70899
EC Epiplan Neofluar 50x / 0,80 EC Epiplan Neofluar 100x / 0,90 (HR) EC Epiplan Apochromat 50x / 0,95 EC Epiplan Apochromat 50x / 0,90	9011-70901
EC Epiplan Neofluar 50x / 0,80 (HC) EC Epiplan Neofluar 100x / 0,90 (HC) Long Distance EC Epiplan Neofluar 100x / 0,75	9011-70902
Long Distance EC Epiplan Neofluar 20x / 0,22 Long Distance EC Epiplan Neofluar 50x / 0,55	9012-10957
Epiplan-Apochromat 150x / 0,95	9444-48000

- Plug the auxiliary microscope into the place of one eyepiece. If such is not available, just remove one eyepiece. Now look into the auxiliary microscope or simply into the eyepiece aperture and turn on the analyser potentiometer until a black extinction cross becomes visible. For an idea on how this cross looks like, refer to figure 37 "DIC adjustment: Typical observations" on page 65.
- Now, on the analyser a white mark should be visible in the middle of the front window.
- With the control panel, go to teach mode by pressing the objective or reflector button together with the **AUX** key for a couple of seconds. The teach mode is indicated by a blinking **AUX** LED.
- Put an unstructured object, like a mirror or a wafer on the stage and look in the eyepiece. The image has to be more or less dark; in the auxiliary microscope the extinction cross or just darkness should be seen.
- Take out the auxiliary microscope and replace it by the common eyepiece.
- Push in the DIC slider for the objective that is currently in use. If installed for the very first time, dust protection inserts need to be removed from the DIC slider locations. The DIC sliders are pushed into place until a distinct „click“ can be heard.
- In the eyepieces, most likely interference colours will become visible.
- Move the DIC slider back and forth by turning the tiny adjustment screw at the protruding end until one broad dark strip can be observed, that moves diagonally into the field of view. If a wrong DIC slider is used, usually more than one strip can be seen; they are usually not so wide as to cover the entire field of view. Beyond the dark strip there are colours which change from blue to yellow.

- If the one broad dark strip is visible, it is adjusted by rotating the analyser in such a manner, that a homogenous image is achieved at maximum DIC contrast.

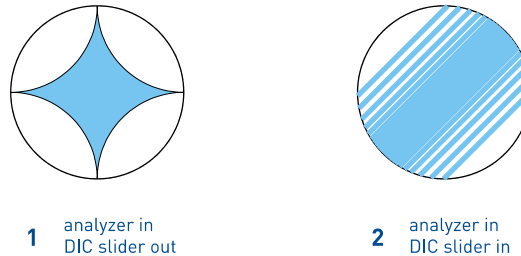


figure 37 DIC adjustment: Typical observations

- Further enhancement of the DIC contrast is possible by a smaller aperture diaphragm when using DIC. A good average is about 50% of the pupil diameter of the objective actually used.
- Repeat the whole procedure for each objective that is equipped with DIC.
- For each objective, do not forget to store the setting after adjustment by pressing the **AUX** key.

5.4 Microscope Chuck (Reflected Light Operation)

The microscope chuck is usually maintenance-free. The only setup that is relevant for service purposes is the levelling of the vacuum chuck. This procedure - if missing - may have several consequences:

- Wafers may come in contact with the objective
 - An oblique wafer chuck acts like a wedge and may touch the objective when the adjustment has not been made at all, i.e. if the amount of obliqueness is bigger than 150...200 µm. This consequence is rather unlikely, as other consequences become apparent more easily, such as those that are mentioned below.
- The autofocus loses track when the stage moves across big distances.
 - The laser autofocus works by a principle of a closed loop, which has a certain cycle time between the signal read-out and the activation of the focus drive. If the focal plane is dragged out of the catching range of the autofocus within one correction cycle, the autofocus cannot re-focus and the image is not longer crisp. This is the most frequent indicator that a stage levelling is necessary. It will occur with the 100x - or even worse - the 50x magnification.
- In CSM mode, colour changes across the field of view when a flat sample is observed.
 - The confocal scan mode resembles height differences on the specimen by different (false) colours. A flat, even, but oblique sample - and every sample will appear oblique if the chuck is not levelled correctly - will cause changes in the colour that is represented in CSM, since the distance between objective and sample is different from one side of the field of view to the other.
- In brightfield or DIC, not all parts of the sample are imaged sharply.
 - This behaviour is similar to the effect in CSM. The focal plane of the objective is not parallel to the sample surface and so parts of the sample are imaged not sharply.

To level the sample stage correctly, first a basic understanding of the mechanical design is required.

5.4.1 How The Chuck Is Levelled

The vacuum chuck is mounted onto the microscope stage by means of three screws, that are located at the circumference at 120 degrees. Each of the screws protrudes through the chuck and is screwed into the top plate of the microscope stage (1 in figure 38). A packet of bowl-shaped washers (2 in figure 38) acts as a compression spring and applies a counter force if the screw 1 is tightened.

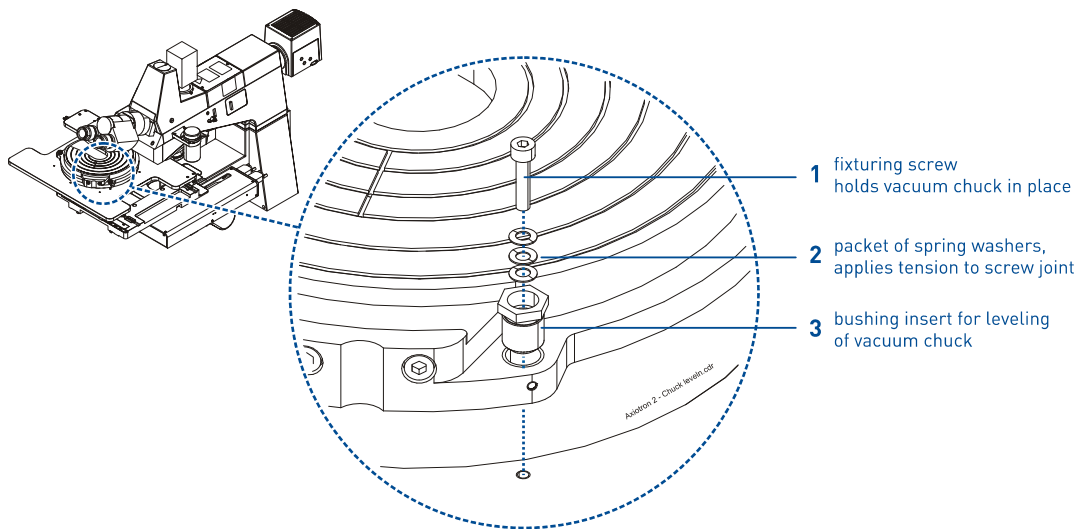


figure 38 Mechanical design of chuck suspension

Levelling becomes possible by the design detail, that the set screws 1 do not simple protrude through the chuck, but are held in a bushing (3 in figure 38), which is inserted into the chuck using a fine screw thread. A hexagon head of these bushings allows to rotate them in their fine thread. The bottom of the three bushings forms a three-point suspension for the chuck. The washers make it possible to level the chuck against their counter force, as otherwise (screw 1 is tight) no adjustment at all would be possible.

5.4.2 Levelling Procedure

The following tools are required:

- Allen key 3 mm to adjust the set screw (1 in figure 38) so that the spring package is properly engaged
- Spanner 13 mm to actuate the bushing insert (3 in figure 38) to level the chuck

To have a better control over the action taken, it is a good idea to define one point on the wafer as a fixed or reference point and two points as variable. To make it easier, the least accessible of the three wafer suspension points (usually the one on the rear of the chuck) will be defined as fixed. This one will not be adjusted at all. All adjustments are done with the two remaining suspension points on the front of the chuck.

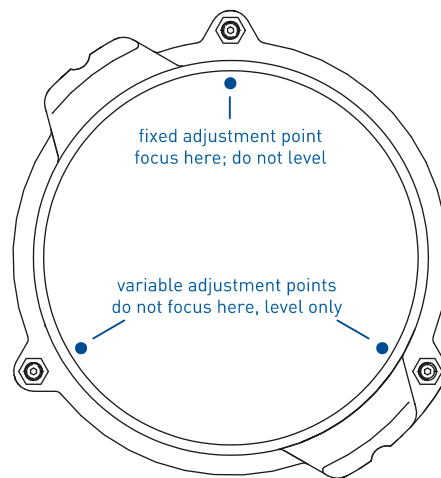


figure 39 Levelling points on wafer (top view)

- Slacken the set screws (4 in figure 38) of the two variable chuck suspension points on the front of it. Using the 3 mm Allen key, test the tension of their compression springs. The set screws (1 in figure 38) should be set so tight as to compress the washers a bit, but not fully, i.e. they are not supposed to be tight in the strict meaning of the word.
- Deactivate the autofocus, if the system is equipped with it. Ensure that it is kept off during the entire process.
- By joystick, go to the fixed adjustment point.
- Manually focus onto the wafer surface, using an objective of medium magnification. A 20x will do for the first round.
- By joystick, go to the first variable adjustment point. While keeping the focal position where it is, adjust the bushing (3 in figure 38) until the wafer is in focus.
- If the amount of adjustment is too big, the appropriate range of the tension of the compression springs will be left. In this case readjust the tension using the 3 mm Allen key and screw 1 in figure 38.
- Repeat this step with the second of the two variable points.
- Go back to the reference point and refocus manually. Do not adjust anything.

- In the same way, go another few rounds between the reference point (refocus manually, do not adjust) and the variable points (do not focus, but adjust bushing 3), until all three points appear sharp without the requirement to adjust anymore.
- Repeat this entire procedure first with the 50x objective and - if the result is satisfactory - with the 100x objective or any visible light objective with the highest possible magnification.
- The procedure of levelling the chuck is so far accomplished. It is a good idea to continue with the adjustment of the upper Z limit setting. This adjustment has become necessary, since the levelling of the chuck has also altered the absolute height of it.

5.5 Adjustment Of The Upper Limit Of The Focus Drive

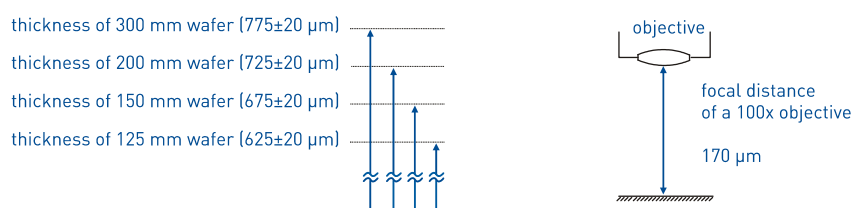


CAUTION

Before the mechanical upper end stop of the microscope's focus drive is aligned, make sure that the chuck is aligned strictly parallel to the focal plane of the microscope. If this prerequisite is not fulfilled, it may happen, that the upper focus limit is adjusted accidentally at a place with a bigger distance between chuck/wafer and microscope lens, and that the lens will crash into the sample when the stage moves.

Refer to "Microscope Chuck (Reflected Light Operation)" on page 65 for details on how to align the parallelism between stage and objective.

The adjustment of the upper focus limit will only work, if wafers of only one thickness are used on the system. If, for example, wafers with a diameter of six and eight inches are used, it may happen, that either one wafer type (the thinner one) never gives crisp images, especially at higher magnifications, or the other wafer type (the thicker one, i.e. the 8" wafers) may cause contacts between objectives and wafers.



Axiotron 2 - Walendowski

figure 40 The thickness variation of wafers with different diameter makes a setting of the upper Z limit impossible, due to the small working distance of the high-mag lenses. The above drawing is by scale.

The wafer thickness for different wafer diameters according to SEMI specification are shown in the sketch below. Keep in mind, that a 100x objective may have a working distance of as little as 170 μm . In this tiny distance, the following contributions must be taken into account:

- the thickness tolerances of the wafers (worst case: 40 μm)
- the inevitable un-parallelism of the chuck (approx. 5 μm)
- an inadvertently introduced focussing error caused by different vision and eye accommodation of the observer(s)
- the potentially imperfect levelling of the chuck and
- a safety distance

To adjust the focus limit, the following tools are required:

- Allen key 2.5 mm
- a test wafer of exactly the same type as used during common operation

The adjustment is always done with the objective with the closest working distance. It is important, that during this adjustment specimen, stage and wafer holder have to be the same as during common operation. This means, it makes no sense to adjust the upper Z limit with a 6" wafer, if the normal operation is done with 8" wafers. As shown above, this adjustment depends on tenths of a millimetre so that the work has to be carried out very carefully.

- Select the objective with the smallest magnification (such as a 5x) and move the stage as far down as possible by turning the coarse drive knob anti-clockwise.
- At a certain point the stage will not follow anymore. A mechanical (lower) end stop is engaged. All washers (see figure 41) are lined up, and the blocking pin 1 (in figure 41) forms the end of the washer stack.
- Slacken the set screw 2, which can be accessed via a hole in the coarse drive knob from the front or which is accessible behind the focus drive cover at the left side. A 3 mm Allen key is required.
- The inner flange 1 is now free to move.
- Move the coarse drive knob down by another one or two turns, then tighten set screw 2 and repeat the same procedure, but with an upward focus drive movement.
- If the focus drive blocks at the upper end, the focal range will probably not yet be reached. But, after slackening of set screw 2, every further upward movement of the focus drive will also shift the inner flange with the blocking pin. Whenever set screw 2 is now tightened, the upper end stop is immediately established.
- Switch in a 10x objective and pull on the pushrod for the field stop in order to close it.

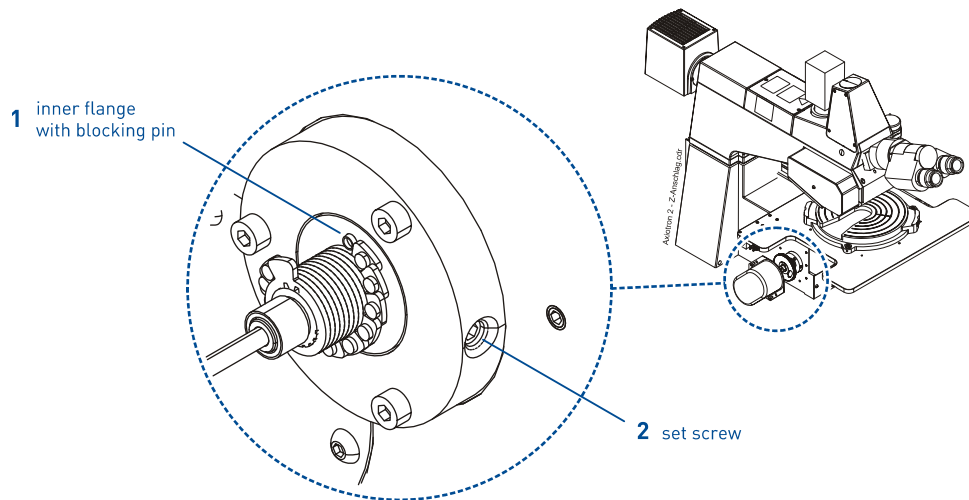


figure 41 The left-hand side of the focus drive

- Move the stage upward using the focus knob on the control panel while watching the image in the eyepieces.
- If the image becomes crisp and the washers haven't blocked the upward movement yet, even though the set screw (2 in figure 41) was tightened, the amount by which the inner flange was rotated did not suffice. Repeat this procedure from the beginning and let establish the lower end stop at a lower position.
- If further upward movement is blocked and the image is *not yet* crisp, the correct precondition for the adjustment has been achieved.
- Slacken the set screw (2 in figure 41) and carefully move the focus drive further upward.
- If the Z drive does not move anymore, it might be required to press the *RESET* key on the microscope control panel to override the soft limits of the focus drive.
- Never move the focus drive backwards, i.e. in a direction that would lower the stage, as this would not make sense. The idea is to have the upper end stop engaged at all times during this procedure, but not yet locked by the set screw.
- *Do not yet go into focus*; it is sufficient to reach a region that is close to the focal plane.
- If the arrival at the focal plane can be expected soon, stepwise increase the magnification and approach to the focal plane in the manner that has been described above.
- Carefully approach and go into the focal plane with the objective with the closest working distance. This is not necessarily the objective with the highest magnification, since also „long distance“ lenses are available and might be installed.
- If the image in the eyepieces is crisp, move the focus drive a tiny bit higher, but not so far as to touch the specimen with the front lens. This is the tricky part of the alignment. Going beyond the focal plane by about 20...30 µm should be sufficient.
- Fix set screw 2.
- Move the focus drive backward in order to lower the stage and carefully move it upwards again. Watch the protection mechanism work. If the right-hand side cover

of the Z drive is taken off, it is also possible to use the coarse drive knob for the upward motion.

- Try the end stop a few times more. On the one hand, it is important, that it is impossible for the objective to touch the specimen, even when the objective revolver changes position, on the other hand it is important that the specimen can always be brought in focus without touching the newly adjusted upper limit.



CAUTION

Insufficient play of the Z drive between focus position and end stop would cause the mechanical drive to touch the hard limit any time a specimen is brought into focus. At the border-line condition „focus=limit“ the mechanics of the Z fine drive is mechanically overstrained, which results in mid-term damage of the drive. For that reason it is important, that the focus point (for all objectives!) maintains a certain distance to the mechanical limit.

- If it is obvious, that in case that the limit has been pushed upward too far, the inner flange with the blocking pin may be manually rotated back clockwise which equals to start the whole procedure over.

5.6 Install Reflector Cubes

A list of commonly used reflector cubes can be found below.

Reflector	P/N	Remarks
Brightfield	9452-88500	
Brightfield for AF operation	9452-88900	
Darkfield	9452-88600	
DIC for variable analysers	9452-88700	requires DIC equipment
DIC with built-in fixed analyser	4500-00064	requires DIC equipment
CSM reflector „Chromat C“	9450-05800	requires CSM head
CSM reflector „Chromat 0“	9452-25500	requires CSM head
Brightfield DUV	9452-82800	requires UV-capable stand
Brightfield i-line	9452-82900	may require UV-capable stand
Fluorescence (empty cube)	9452-88800	requires filter set

To install or remove a reflector cube, proceed as follows:

- Remove the protective plexiglass cover, if it is installed. To do so, remove the two 3 mm allen screws, take off the plexiglass shield and pull out the aluminium sockets.
- There are two more 3 mm Allen screws behind (see figure 42). Slacken them and take off the reflector revolver cover.
- To remove a reflector cube, slacken the two allen screws that hold it in place using a 2.5 mm allen key. Take care not to remove the screws that hold the cube together: the correct screws are mounted *horizontally*.

- Upon removal, mind any possibly attached aluminium foil at the back of the cube and keep it with the cube and at exactly the same place. These foil pieces are sometimes required to equalize finest optical tolerances. They are the best trade-off between effort and benefit.

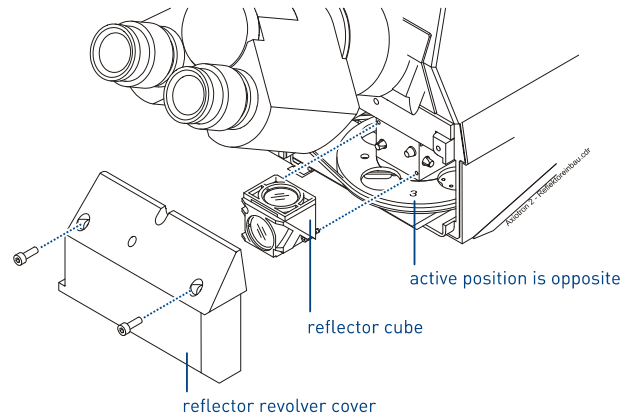


figure 42 Exchange of reflector cubes

- To install a new cube, first locate the correct revolver position. There are white numbers engraved in the revolver body, that represent the number of the reflector button at the control panel. The actual working position of the reflector cube is at the back side of the revolver. i.e. if a reflector on position 3 needs to be installed, it is required to press the reflector key No. 1 on the control panel to bring reflector seat number 3 to the front.
- After installing the cube, attach the enclosed round label to the corresponding reflector button at the control panel.
- Some contrast modes may require additional settings with the microscope's firmware, such as to switch illumination mirror positions or to activate the CSM module. For such settings, kindly contact our Service Department.

5.7 Install Objectives

The Axiotron 2 microscope is equipped with a revolver that features five objective ports. All Zeiss microscope objectives with a *M27x0.75* or with a *RMS W 0.8* thread can be used. For W 0.8 objectives, an adapter ring (P/N 9010-95168) is available.

The objective revolver is motorized, i.e. it can be controlled by the microscope's control panel as well as per RS232 command. The positions are coded, which means, that the microscope can recognize the current objective position even if the revolver is moved manually. Depending on the currently active objective, several actions can be automatically triggered by the microscope's firmware, such as a parfocal or parcentral correction, if an Autofocus controller or a MCU28 motor controller are present.

To install a new objective, proceed as follows:

- Using the control panel, switch the microscope to the objective position that is to be installed.
- Lower the sample stage to the lowest possible position and remove any present samples.
- If the position was unused before, first remove the plastic dust protection cover in the respective revolver position.
- Unpack the objective.

CAUTION



Take care to store an objective always in the protective plastic box. Outside that box, always place it upright onto the table, *with the thread facing down*. This prevents dust from falling into the back aperture of the objective. In contrary, a contamination of the front lens is easier to remove.

- Screw in the objective. Take care to screw it in tightly, so that it does not slacken during operation later.
- If the microscope is equipped with DIC, it is also necessary to install the correct DIC slider. Refer to 'Setup Of Differential Interference Contrast' on page 63 for details. Also for unused DIC positions, plastic plugs are used to protect the slots and the components behind from dust. These plugs need to be removed prior to the installation of the slider.
- Attach the appropriate round label to the respective objective key position at the control panel.

CAUTION



Axiotron 2 microscopes may be equipped with parfocal and parcentral correction, which is accomplished by the autofocus controller or the MCU28 stage controller. A removal of an objective usually invalidates any of such settings. This fact needs to be kept in mind in case that frequent objective changes are planned. Even the retrofit of the same objective usually requires to re-teach the offsets.

5.8 Illuminators

5.8.1 Halogen Lamp HAL100

5.8.1.1 Lifetime considerations

The halogen bulbs, which are used in the HAL100 illuminators do have a nominal life-time of only 50 (fifty) hours, given that they are driven at their nominal voltage of 12 Volts. This means, in applications, that require an extremely high light intensity (dark-field, CSM, film thickness measurement) the bulb has to be replaced every second day, if they are run continuously.

However, close to the nominal voltage, the life time of the bulb can be drastically improved if the lamp voltage is slightly decreased.

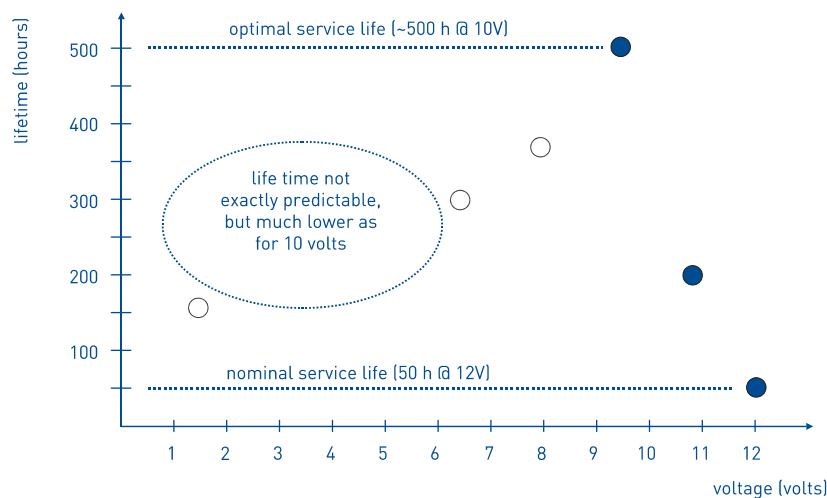


figure 43 Increase of service life by applying less voltage

It is important to know, that for a range of typically 20...60% of the voltage rating, the life time *decreases* again. The reason for this effect is the fact that the halogen cycle does not work properly for too low temperatures and that the filament can break prematurely.

5.8.2 Halogen bulb exchange



CAUTION

Hot surface. Allow the lamp to cool down for about 10 minutes before the bulb is exchanged.

- Unscrew the set screw that holds the lamp housing.
- Pull the lamp housing off vertically.
- To release the old halogen lamp, push with the finger against the little metal rods that are visible at the side of the lamp. Refer to figure 44 for details.

- Take the bulb out and dispose it of. There are no hazardous substances contained.
- Insert the new bulb similarly. Take care never to touch the bulb with bare fingers.
 - Fingerprints contain grease that burns into the glass body of the bulb and shortens the lifetime of it.
 - If the glass body is touched accidentally, thoroughly clean the bulb by means of acetone, dry the lamp with a lint-free cloth and remove any dust particles that may remain on its surface.
- Most lamps are shipped in a small paper or polyethylene bag. Open the bag at the side with the contact pins, insert the lamp, release the metal rods to let the mechanism grip the lamp contacts and finally pull the bag off. Newer lamps, such as the HAL100 with HSEB catalogue number 9423-00000 as shown in figure 44 will have a lamp insertion tool included, that makes the exchange of the bulb much easier.
- Put the lamp housing back onto the halogen lamp.

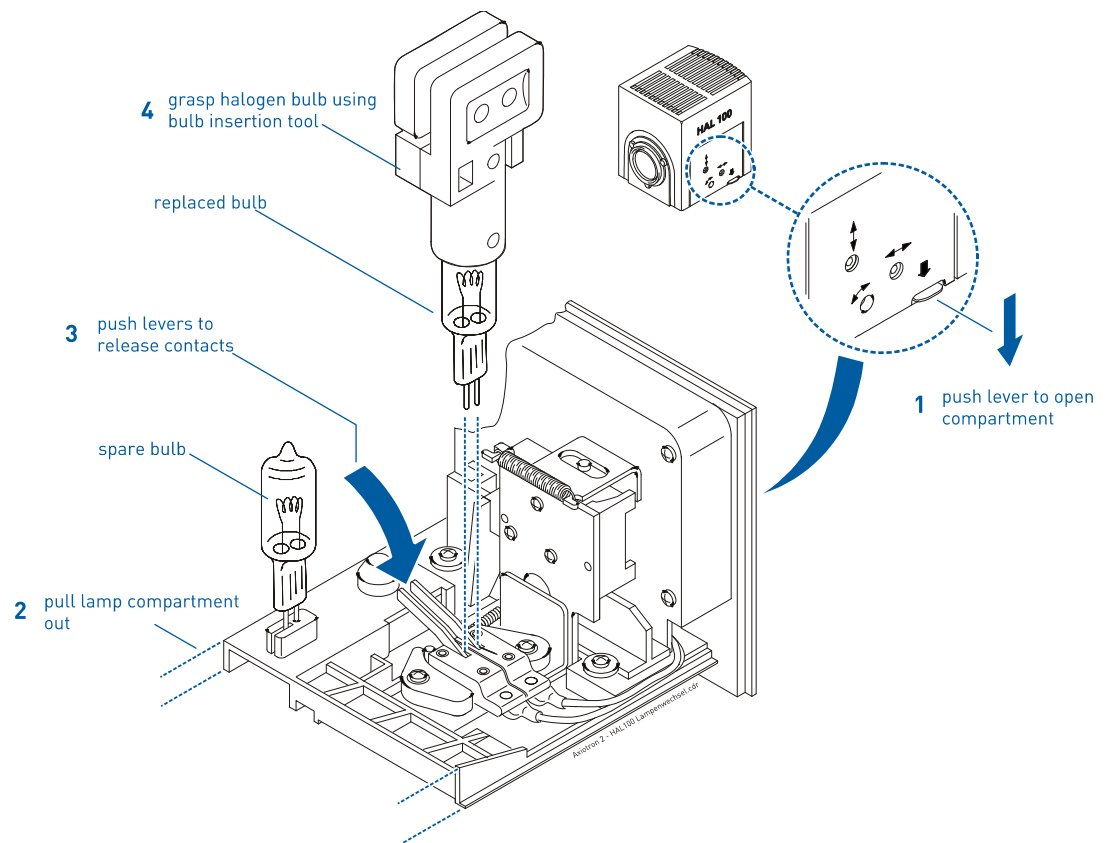


figure 44 Halogen Lamp bulb exchange. The HAL100 has been shipped in three different variations over the last ten years. Despite of several changes in the optical appearance of the lamp, the basic technical design remained unchanged.

- In certain intervals, check the lamp cable for thermal corrosion. See "Heat protection filters must be removed, if the microscope is equipped with a near-infrared spectrometer, since such a spectrometer also requires the wavelength range above 750 nm in order to work properly. The installation of both a laser autofocus and a NIR spectrometer is incompatible." on page 77 for details.

- Perform the lamp alignment as described in “HAL100 lamp adjustment” on page 76.

There might be a complaint about the short lifetime and the high price of the original halogen bulbs. The reason for the higher price is the fact, that the bulbs are manufactured exclusively for this microscopy purpose. Other bulbs, such as from hardware stores, feature a bigger filament area. The larger area causes less thermal stress which is beneficial for a high lifetime. However, some imaging modes, such as darkfield, DIC and especially CSM require a point-like source of light with extremely high intensity. In other words, the larger filament of simple bulbs from hardware stores is good for a higher lifetime, but the light is not generated at the spot where it is required. In figure 45 the loss of about 50% image brightness is clearly visible.

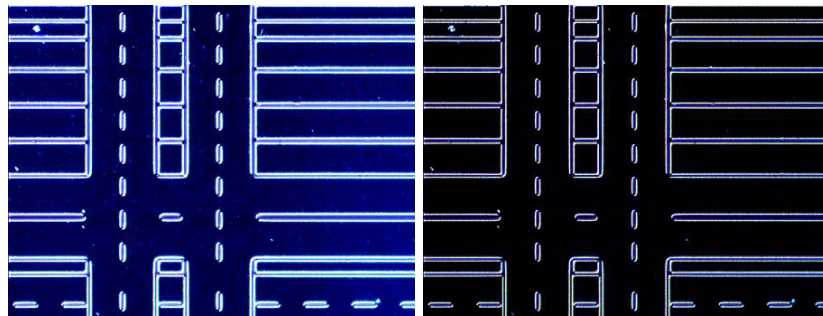
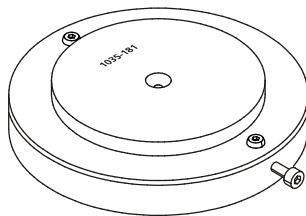


figure 45 Comparison between original and 3rd party bulbs in DIC

5.8.2.1 HAL100 lamp adjustment

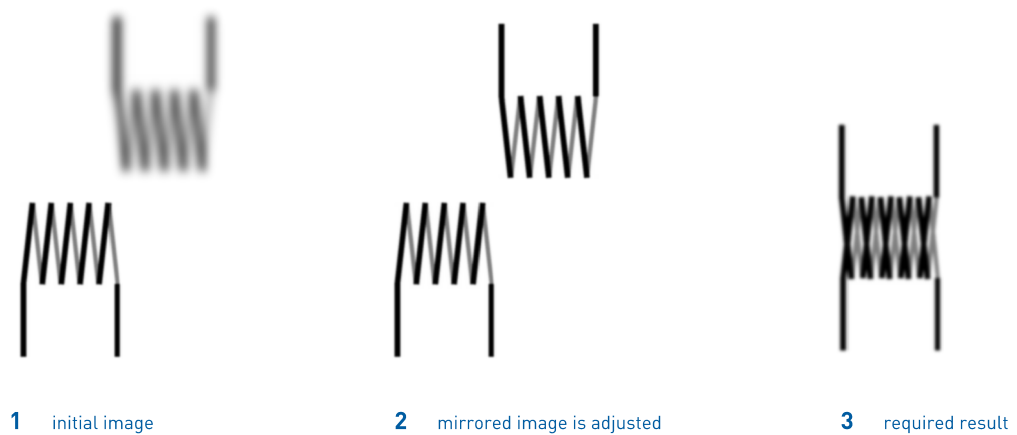
For the lamp adjustment, the adjustment tool (HSEB P/N 9010-35181) is recommended.



Axiotron 2 - Lamp Adjustment Diaphragm.pdf

figure 46 Lamp Adjustment Diaphragm 000000-1035-181

- Mount the adjustment diaphragm to the dove-tail of the halogen lamp and direct the light beam to a white, even surface that is about 30 cm (1 ft.) away. Even the microscope body might be used for this.
- On the screen an image as shown in 1 of figure 47 can be seen. The image usually contain both the filament of the lamp as well as a fainter, reversed image of the reflected image.



Axiotron 2 - HAL 100 adjustment.pdf

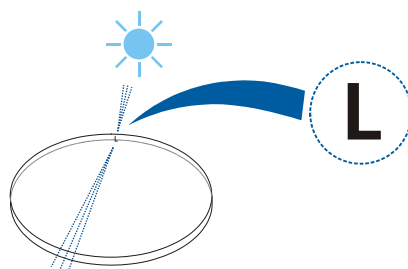
figure 47 Adjusting the halogen lamp HAL100

In the first part of the adjustment the lamp collector is adjusted to obtain a crisp image of the reflected image of the filament. In the second step of the adjustment the filament is superimposed with the filament, so that both form a evenly illuminated square, in which the filament of the reflected image fills the gap of the non-reflected image. refer to figure 47 for details.

5.8.2.2 Notes on heat protection filters

Heat protection filters in the halogen lamp block all light above 750 nm, which does normally not contribute to a microscopic image, but heats up the interior of the microscope and the specimen and disturbs the correct function of the laser autofocus. As the interference coating of the filters may have tiny impurities that allow a certain amount of light to pass through, usually both the halogen lamp as well as the microscope stand are equipped with such a filter.

Heat protection filters are always required, if the microscope is equipped with a laser autofocus.



Axiotron 2 - Wärmeschutzfilter.pdf

figure 48 Finding the correct side of a heat protection filter by looking against a bright light source

Heat protection filters must be removed, if the microscope is equipped with a near-infrared spectrometer, since such a spectrometer also requires the wavelength range above 750 nm in order to work properly. The installation of both a laser autofocus and a NIR spectrometer is incompatible.

During preventive maintenance, always verify intactness and correct setup of the heat protection filters. Both filters must be present. If the filters seem to be soiled or scratched, clean them with a soft cloth and optics cleaner or replace it.

If the heat protection filters are inserted into the lamp or the illumination port, take care to insert them in the correct direction. At the outer edge of the filters there is a small letter **L** engraved, which must point *towards the lamp*. By observation of the edge against a bright light source the correct side of the filter can be determined easily.

5.8.2.3 *Check of lamp contacts for thermal corrosion*

In the past, several problems on HAL100 lamps arose from bad electrical contacts. The high heat impact on the contacts of the halogen bulb may thermally stress the screws that hold the contacts. As a result, the tension that has been applied in the factory to ensure a firm contact may decrease, transfer resistance will increase, additional heat will be produced and finally the electrical contacts and the cable will be destroyed.

To ensure good electrical contacts, open the small plastic cover at the bottom of the lamp by means of a small Phillips screwdriver and inspect the electrical contacts. No extraordinary heat impact should be visible there.

If corrosion caused by overheating is observed, exchange the lamp cable and the screws and carefully clean the mechanical contacts before the lamp is reassembled. Only use high quality screws, if possible, those made of non-corroding steel.

It will be enough to repeat this procedure once per year.

When the plastic cover is reassembled, make sure to find the same screw threads in the lamp housing that were cut by the screws before.

5.8.3 **High-Power Xenon Light Generator LG Xe 180W remote („Medexxa“)**

The LG Xe 180 W remote by Medexxa is the common high-power light source for the Axiotron 2 microscope. Wiring of the light generator is limited to establishing the remote cable connection for the intensity control and the connection of the liquid light guide between the generator and the microscope.

5.8.3.1 *Installation requirements*

Since the Medexxa light generator produces a remarkable amount of heat, some precautions need to be observed, if the unit is to be relocated. This is especially important if the generator needs to be located at another point than designated.

- Do not install the Medexxa generator in a closed cabinet, such as a rack, whenever possible. Locations specified by HSEB have been verified and are acceptable.
- If it needs to be installed in a closed cabinet, take care that the cabinet has air ventilation grids close to the fan exhausts at the back side of the light generator.
- Leave 15 cm (6“) space between the back side of the light generator and any adjacent cabinet wall to ensure proper air circulation.
- On installation in the USA, please double-check, if the AC mains is wired correctly. Mixing up the hot and the neutral wire causes the fuses to burn and might damage the light generator.
- Correct fusing for the light generator is done with 3.15 Ampere slow-blow; even if older generators should indicate a different rating.

5.8.3.2 Lamp lifetime supervision

On the front panel of the light generator a bargraph LED display can be found, which counts the elapsed operation time of the current arc burner. After powering the light generator on, the LEDs will perform sort of a function check. At the same time the lamp attempts to ignite the burner. If ignition is successful, the current elapsed lifetime (not the remaining life time as indicated on the label) is displayed.

The absolute life of arc lamps (i.e. until failure) varies and cannot be predicted for a particular lamp. The „service life“ is an empirical quantity. Within service life, failures are rather improbable. For the XBO 180 W lamp that is used in the Medexxa light generator, a service life of about 1.000 hours is specified. This is the mean time in which the intensity drops to 75% of the initial level. This specification is based on the assumption that the lamp is operated for 30 minutes per ignition. Frequent ignition (switching on and off) will reduce lamp life, such as to 500 hours if the generator is power-cycled 30 times a day.

Irrespective of the decrease in radiation intensity and irrespective of the number of ignitions, lamp life is limited by material fatigue and the resulting higher risk of burst. This considered, a high-pressure xenon arc lamp must never be operated for longer than 1.000 hours.,

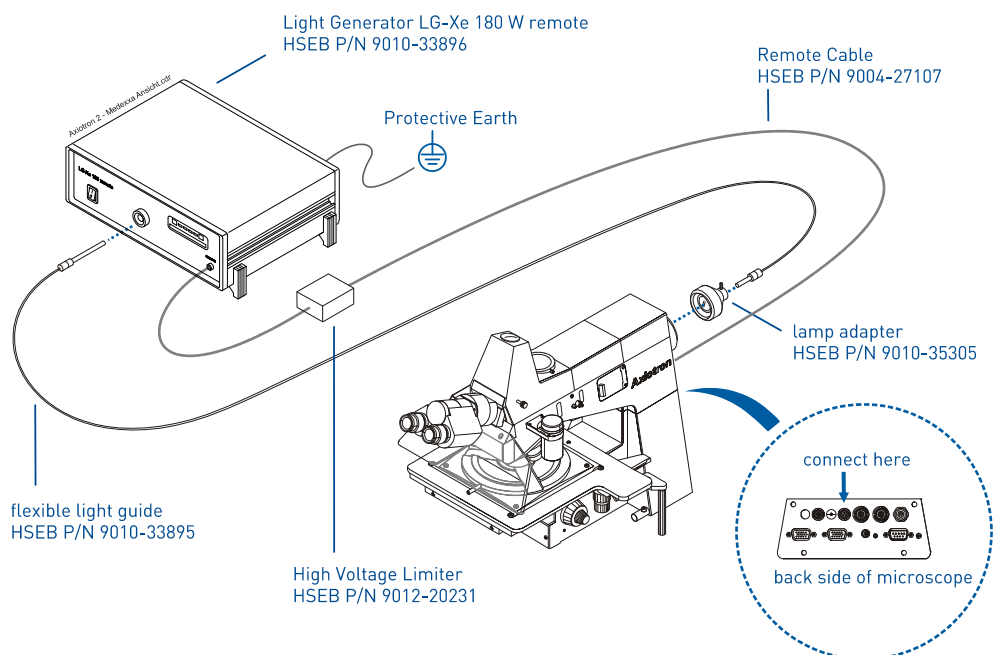


figure 49 The „Medexxa“ light generator, connected to the Axiotron 2

5.8.3.3 Xenon lamp exchange

- Switch the light generator off. Wait at least 15 minutes to allow the lamp to cool down.
- Remove the mains cable.
- Unscrew the four knurled head screws on both sides of the cover. Lift the cover off. Mind the ground cable connected to it. Leave this cable on.
- Disconnect the illuminant. To do so, lift the connector of the PCB-style pole (1 in figure 50) and pull both ends apart. There are brackets that need to be pressed to allow disconnection.
- Slacken the tiny set screw (3 in figure 50) of the lamp holder a little (about one turn, anti-clockwise).
- Unscrew the knurled head screw (2 in figure 50) and unlock the lamp holder by opening the bracket.
- The old illuminant can now be removed by pulling it carefully backwards.

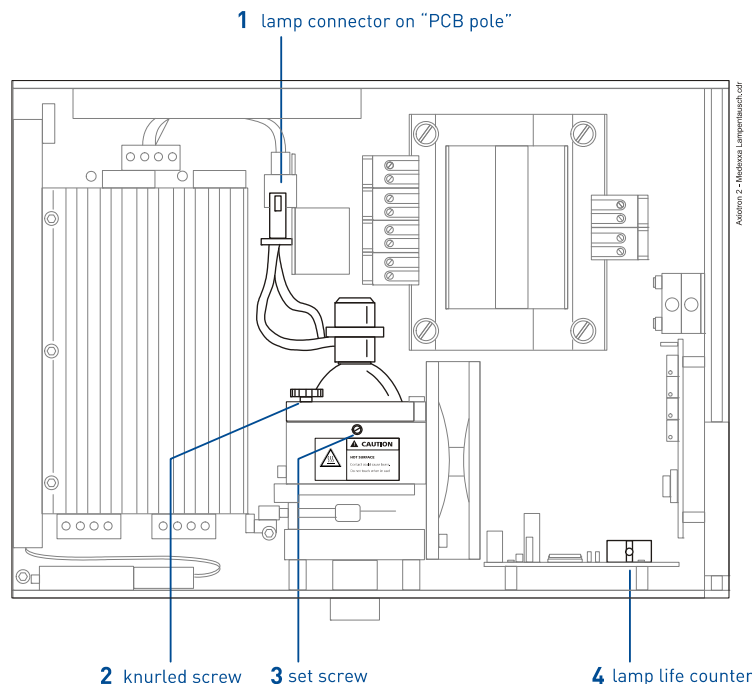


figure 50 Exchanging the illuminant in the Medexxa light generator



CAUTION

The illuminant is under high pressure, even in cold condition. Observe all safety advices given by the manufacturer of the illuminant and also carefully read the section 'Legal Matters' on page 6ff of this handbook.

In addition, never direct the illuminant to other persons. Immediately after removing the used illuminant, store it in the original box where the new illuminant was delivered in.

- After insertion of the new illuminant, lock the lamp holder and tighten the knurled head screw. The lamp is adjusted automatically. The tiny set screw is *slightly* fastened and the electric connection is re-established. It is fail-proof against wrong connection.

**CAUTION**

Although the illuminants for the Medexxa and the HXP light generators have the same mechanical form factor, they are incompatible and cannot be exchanged.

- The lamp's operation time counter is re-set by pressing the red knob (4 in figure 50).
- Put the top cover back to the Medexxa light generator and tighten the four knurled head screws that hold it in place.

5.8.4 HXP High Power Illuminator

The Axiotron 2 may be equipped with a high-power microscope illuminator, that is based on a metal halide arc burner and which unifies both an extremely high intensity with an exceptional high service life of typically 2.000 hours. The high intensity of the illuminator allows the detection of finest darkfield defects and is also suited for bright-field and DIC images.

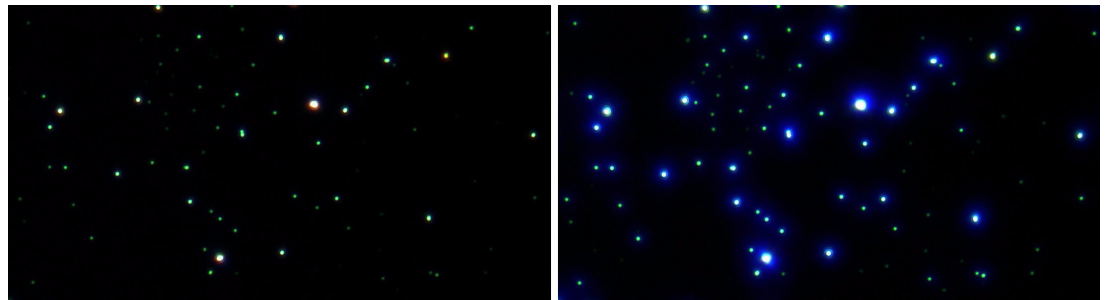


figure 51 Image brightness comparison between 100 watts halogen lamp (left side) and the high-power illuminator that may be used in the Axiotron 2 (right side)

5.8.4.1 Remarks on CSM mode

The high-power illuminator is *not suited* for CSM mode. For CSM-VIS a traditional HAL 100 illuminator is used.

5.8.4.2 Remarks on Brightfield mode

For brightfield images, using the high-power illuminator on samples with transparent or semi-transparent films reveals colour modulations in the image, which are not visible with traditional illuminants, such as halogen or xenon lamps. The reason for this behaviour of the high-power illuminator is explained below.

The emission spectrum of the high-power illuminator is dominated by two lines in the green and yellow spectral range. Another group of strong lines in the blue and violet range is usually cut off by the yellow filters that are commonly used in fab areas that deal with resist handling. Although also available in the spectrum, other colours are

much less intense and their contribution to the image can be neglected. In comparison to this light source, traditional microscope illuminators, such as incandescent lamps like halogen illuminators, but also arc lamps like xenon arc burners, have a much more homogenous spectrum than the metal halide lamp used in the Axiotron 2.

When light is reflected by samples with (semi-)transparent films, part of the light is reflected at the air-film transition, while another part is reflected at the film-substrate layer. Both reflected light waves interfere with each other on its way to the camera. For each light wavelength a certain film thickness forms a constructive interference producing a higher signal in the camera. This happens if the additional optical path of the light reflected at the back side of the film equals an integer manifold of the light wavelength. For an optical path difference of uneven manifold the interference is destructive.

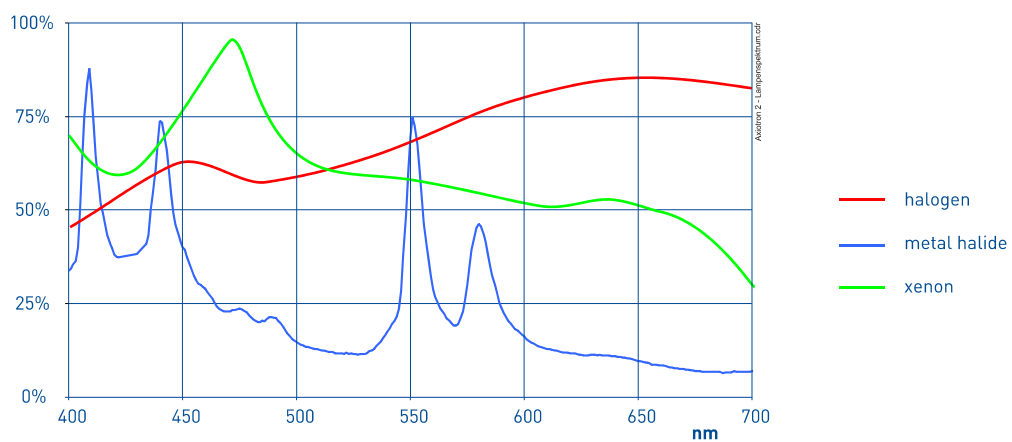


figure 52 Lamp spectra of metal halide lamps vs. halogen and xenon illuminators.

If a monochromatic light source is assumed, the image brightness is therefore modulated depending on the film thickness. Having just two dominating lines (as for the high-power illuminator) the modulation can be still clearly seen as intensity and colour structure in the image. For light sources with a continuous spectrum this effect occurs as well, but as the modulation pattern shifts slightly for each wavelength, the overall image does not show any modulation anymore due to averaging.

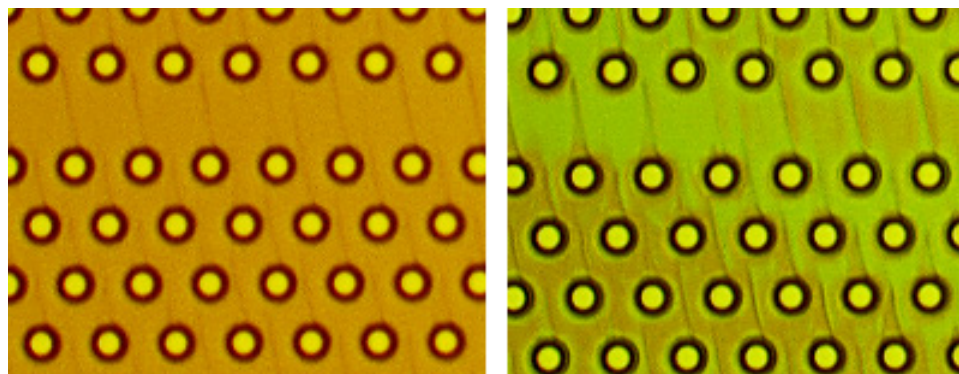


figure 53 Brightfield images of samples with transparent layers, images with xenon illuminator (left) and metal halide illuminator (right)

In summary, the observed colour pattern in the images is direct effect of the thickness changes of the transparent resist film on top of the imaged structure and the emission characteristics of the microscope illuminator.

Qualitative measurement of the observed stripes is not possible, however. Since the number of the light wave oscillations inside the film is not known from the image, a total number about the inhomogeneity cannot be given. However, the variation needs to be at least in the order of the used wavelength, hence in the actual case at least in the order of some 100 nm. The colour lines in the image can be compared to height lines at a topographic land map. Furthermore, the smaller and denser the lines are in the image, the steeper is the film thickness gradient.

**NOTE**

If this effect is not desired or has other disturbing effects for common brightfield microscopy, other alternative light sources are available, that feature a more homogenous spectrum.

5.8.4.3 Exchange of HXP Illuminant

**CAUTION**

Hot surface.

Allow the lamp to cool down for about 15 minutes before the bulb is exchanged.

- With a 3 mm Allen key, remove the side cover of the illuminator. Mind the warning label and take it serious; the interior of the lamp becomes quite hot during operation.
- Locate the electrical connector and squeeze together the clips that hold the plug in place (1 in figure 54). Then pull the plug out (2)
- If necessary, use a screwdriver to unlock the clips, but mind to pull or push on the lamp side of the connector only. There is a risk of damage to the plug, and it is better to cause the damage at the (disposable) lamp connector than on the lamp -house-side counterpart, as this would require a factory repair of the whole illuminator.

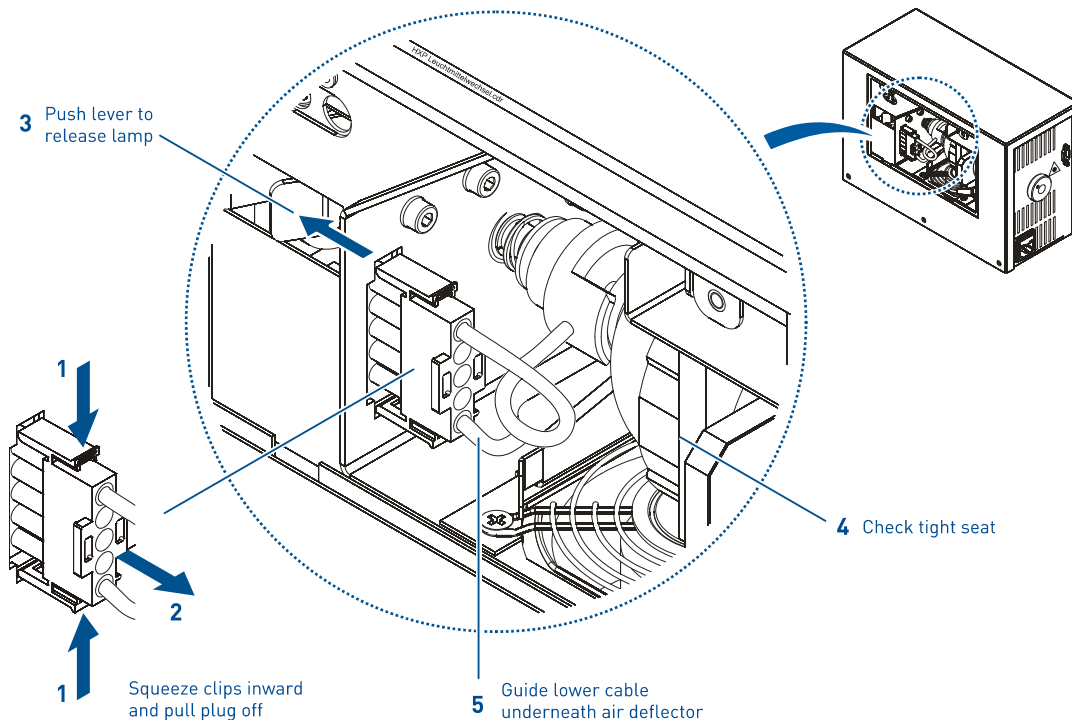


figure 54 How to exchange the illuminant in a HXP illuminator

- Push the metal lever (3) to release the illuminant, then pull the illuminant out.
 - While removing, mind it's cables and their routing. On retrofit, the lower of the two white cables from the illuminant needs to be guided underneath the air deflector left of the cooling fan (5).
 - Inspect the removed illuminant for it's orientation. The front side of the ceramics fitting features a cutout at the rear, which ensures the correct orientation of the bulb inside the lamp house. As an additional help, mind the location of the lamp label, which should usually point outwards. After retrofit, the ceramics collar around the lamp needs to sit tight on the aluminium bracket of the lamp house without any gaps (4).

CAUTION



Although the illuminants for the Medexxa and the HXP light generators have the same mechanical form factor, they are incompatible and cannot be exchanged.

- After exchanging the illuminant, pack the old bulb into the same package as the new bulb was delivered. The bulbs are under pressure, even when cold; and they need careful handling for that reason.
- Re-attach the side cover of the lamp house and put everything back in place.

5.9 Setup of Arc Lamp Illumination for CSM or DIC

The following procedure describes a general setup procedure for arc lamps of the type HBO103, HgXe100 or XBO75, that are mainly used for i-line or VIS CSM mode, but (for reasons of their high coherence) sometimes also for DIC operation.

The lamp alignment consists of two steps:

- rough alignment of illuminant inside lamp
- fine alignment in built-in condition

5.9.1 Rough Alignment of Arc Burner Inside Lamp

The following procedure assumes, that an illuminant has been already successfully installed in the lamp house.

- Locate the adjustment screws at the lamp house and refer to figure 55.

There are three types of adjustment screws:

- *Collimator focussing screw*. This screw changes the focus point of the collimator optics between light source and microscope. Changing focus means, that the electrodes (or their image) is projected on planes in different distances. This applies to projection surfaces, such as a fairly distant wall, but also to the sample plane of the microscope in built-in condition. By turning this screw the image can be either projected as a sharp image or as a diffuse bright circle (which is the case if the collimator is adjusted to meet the focal point).
- *Burner adjustment screws* allow to change the position of the illuminant relatively to the collimator optics, which is fixed. On a projection, it is, so to say, possible to „shift“ the illuminant around. The idea of the alignment is to get the image of the illuminant straight onto the optical axis of the light source.

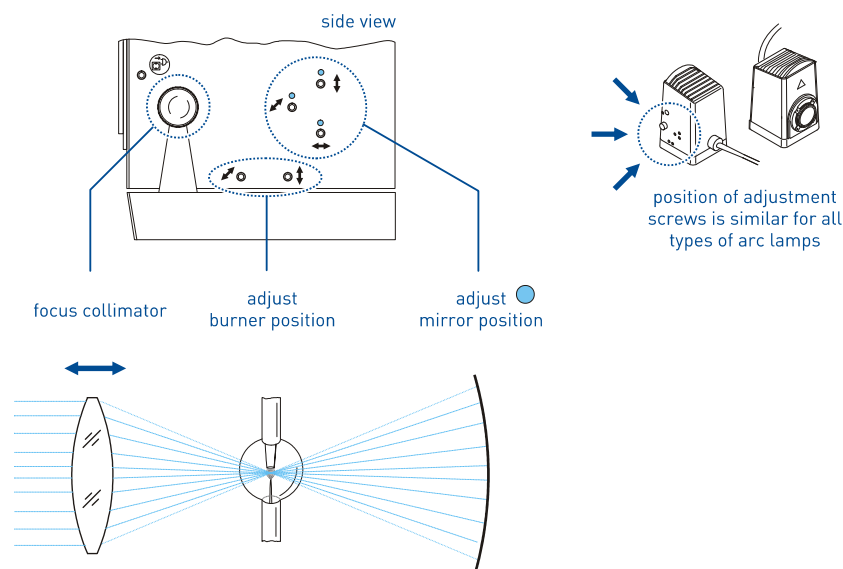


figure 55 Arc lamp adjustment screws

- *Mirror adjustment screws* are marked with a black or red dot. They are used to change the position of a mirror behind the illuminant. This mirror collects the light that is emitted in the direction opposite to the microscope. The focal length of the mirror

is chosen in such a way that the image of the illuminant is projected directly into the illuminant. From the point of the collimator optics, there is no difference, whether the illuminant or the image is to be projected. By adjusting the „mirror“ screws, the mirrored image is brought into superimposition to the illuminant regarding focus and position.

As the arc lamp intensity is quite high and may also contain a substantial amount of UV light, which is dangerous to eye and skin, the very first step is carried out in switched-off condition.



CAUTION

Ensure that the arc lamp light source is switched off and that it is protected against unintentional restoration of electrical power. If in doubt, physically disconnect the cable from the arc lamp to its power supply.

By looking into the *switched-off* lamp house in the direction of the optical axis, the illuminant electrodes should be clearly visible. They are most likely offset and only partly visible.

By adjusting *first* the illuminant adjustment screws (no coloured dot) and *afterwards* the mirror screws, try to bring the electrodes into superimposition as shown in figure 56 below. As the visibility of the electrodes and therefore also the quality of this free-hand adjustment substantially depends on the viewing angle, it is important to look into the lamp house strictly along the optical axis.

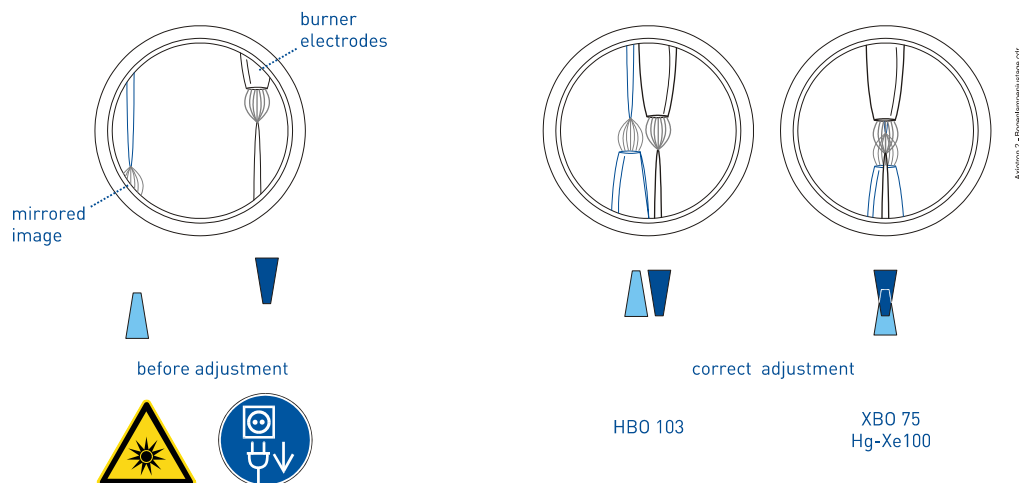
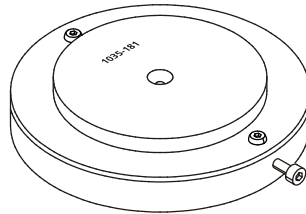


figure 56 Arc lamp adjustment screws

5.9.2 Rough Alignment Against Wall

After this first pre-alignment, connect the lamp adjustment diaphragm to the arc lamp as shown in figure 57, re-connect the arc lamp to the power supply and switch the arc lamp on.



Axiotron 2 - Lamp Adjustment Diaphragm.pdf

figure 57 Lamp adjustment diaphragm

The following adjustment step requires to operate an arc lamp with the beam exposed to the environment. If local working safety regulations prohibit this adjustment, it may be skipped and the fine alignment in built-in condition may follow. Please note, that the fine adjustment may become rather difficult if the following step is missing.

CAUTION



The illuminator's aperture is almost covered by the lamp adjustment diaphragm. Only by a tiny hole, some radiation can be emitted. This small amount of light is used for the alignment of the lamp.

Nevertheless ensure, that the light is not directed at other persons, reflective or flammable materials. Keep in mind that UV light may expose photo resist.

Use a painted surface, such as a nearby wall or the stand body of the microscope as projection screen to perform the adjustment. Work as fast as the required precision allows. If the work needs to be interrupted for any reason, turn the lamp off.

With the adjustment diaphragm attached to the lamp house, repeat the previous step. The idea is to adjust the electrodes of the arc lamp as well as the reflected images, so that both of them are centred in the visible illuminated circle. Proceed as follows:

- Switch the lamp on and wait some minutes, until the lamp does not flicker anymore.
- To obtain a crisp image, first *adjust the collimator* so that the illuminant electrodes are clearly visible. Usually both the illuminant and the image projection can be clearly distinguished. The electrode projection is clearer, while the image projection is fainter and shows less contrast.
- *Refocus the mirrored image*, so that both the electrodes and the mirrored projection are sharp indeed. Do not yet change the lateral position.
- Check if the *electrode images superimpose* as shown in figure 56, while being projected about in the middle of the bright circle that is visible on the wall. Regarding this concentricity, do not exercise too much effort, as the precise centre position of the projection circle cannot be determined with a free-hand alignment.
- For *HBO103* lamps, both arc projections are adjusted to appear adjacent, forming a bright square.

- For *XBO75* or *HgXe100* lamps, which feature a larger electrode distance, superimpose both arc projections, so that they overlap by about 30% as shown in figure 56.

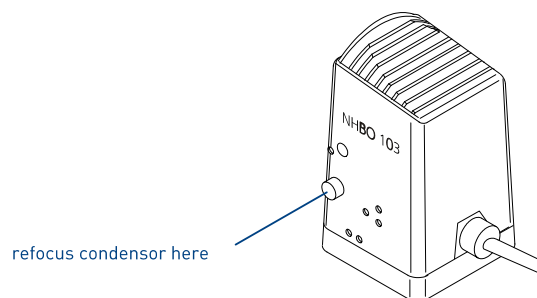
If the alignment is finished, switch the lamp off, remove the lamp adjustment diaphragm and mount the lamp at the correct dove-tail adapter.

5.9.3 Fine Alignment in Built-in Condition

Usually, a painstaking adjustment of the arc lamp outside the microscopes system as explained in "Setup of Arc Lamp Illumination for CSM or DIC" on page 85ff is sufficient for a good illumination of the sample. Therefore, first check, if the microscopic image is well and evenly illuminated by using the checklist below. Only in case, that the results are not yet satisfying, carry out the detailed fine alignment.

Check the current status

- Put a sample on the stage. Focus with low magnification and stepwise increase the illumination up to the maximum in visible light. Refocus, if necessary.
- If the image is sharp in visible light, switch to the 120x UV lens, refocus and check the image quality on the monitor.
- Change the focal setting of the arc lamp using the collimator screw, until the image is best and evenly illuminated.
- With a 3 mm Allen screwdriver, adjust one adjustment screw of the arc lamp after the other *by tiniest amounts* and check, if the image quality is increasing. It is necessary to do this adjustment with direct live feedback from the monitor. If there is no visible change in the live image, *carefully restore the setting it had before the adjustment attempt*. If you are in doubt that restoring the position was successful, go back to "Setup of Arc Lamp Illumination for CSM or DIC" on page 85 and start the entire procedure over, at least the part that involved the fine alignment using the adjustment diaphragm as shown in figure 57 on page 87.



Axiotron 2 - Kondensoranlage Bogenlampe.pdf

figure 58 The collimator adjustment of arc lamps



NOTE

If the preceding adjustment was carried out well, the burner electrodes are usually already at the right place and do only need some minor „tweaking“. The benefit of this method is, that without any effort small improvements can be done in almost no time. Furthermore, it is not necessary to remove the UV camera from it's dove tail adapter.

Precision alignment of arc lamp in built-in condition

- Locate the blue CSM tool box, which contains the adjustment tools for the CSM and take out the adjustment adapter as shown in figure 59 (No. 3).
- Put an unstructured sample, such as a piece of wafer on the stage, find focus and gradually increase magnification until the highest magnification factor in the visible range is reached. Then switch over to the 120x i-line lens.
- Without changing the focus position, switch back to the lowest magnification. This measure ensures, that there is no risk of damage to the UV objective during the next step of the procedure.
- Using a 3 mm Allen key, slacken the three screws at the camera flange of the CSM head and pull out the UV camera with the camera adapter attached.
- Unscrew the camera adapter from the UV camera and put it aside.



NOTE

Always hold the camera with its aperture pointing downwards. Any particle that falls into the camera may cause dark a spot in the image, which can remain permanently visible. Proper cleaning of the camera is a rather sophisticated service task, which means, that extreme caution should be exercised at this step.

- Replace the common camera adapter with the adjustment adapter and put the whole assembly back to the camera port of the microscope. Tighten the three 3 mm Allen screws. A rough angular alignment is sufficient.

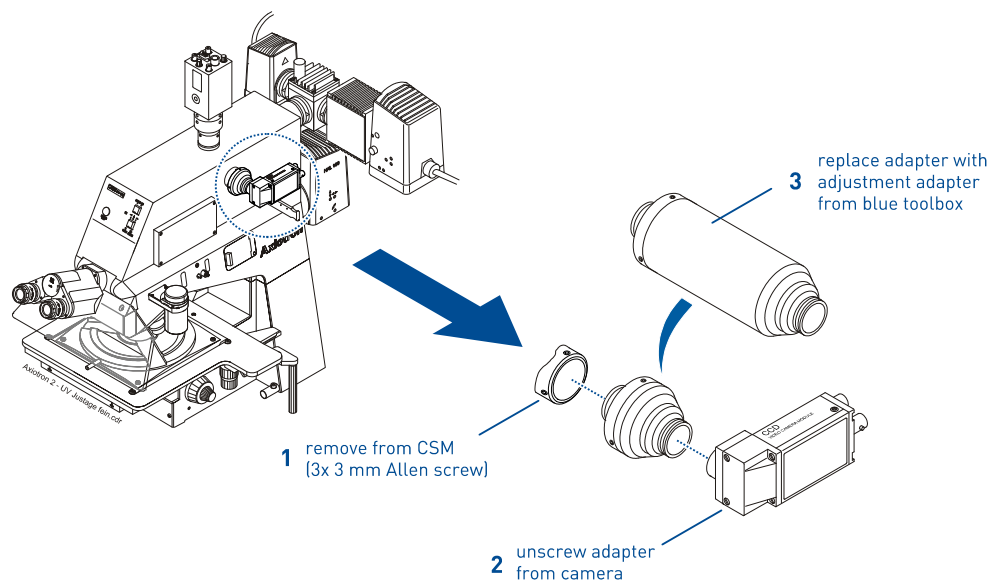


figure 59 Exchange of camera adapter for fine adjustment of UV illumination

- Switch back to the i-line objective. If in doubt whether the focus position has been successfully maintained, it is necessary either to refocus in visible light (and to rely on the correctly taught parfocal offsets between the VIS- and the i-line objectives) or to start the whole procedure over.

- If the procedure was successful, the monitor now shows a bright circle that is formed by the objective's pupil. Of course, as the pupil planes are observed, there is no sample topography visible.
- If the image brightness is too big, use the grey filter slider of the CSM head (see **1** in figure 60) to adjust the intensity. The filter is located at the right side of the CSM head, directly below the UV camera.
- Pressing the **AUX** key at the control panel (see figure 7 on page 25) and turning the aperture knob to the left should cause the visible diameter of the bright circle to decrease. This smaller circle is formed by the aperture diaphragm of the microscope and should look polygonal (in contrary to the objective pupil, which is round).
- The CSM illuminator features a pocket that accommodates the auxiliary lens that is also part of the CSM adjustment tools (see **3** in figure 60).
- If the auxiliary lens is inserted, the burner electrodes become visible in the monitor image.
- A sharp image of the electrodes is achieved by focussing the collimator of the arc lamp (**2** in figure 60).

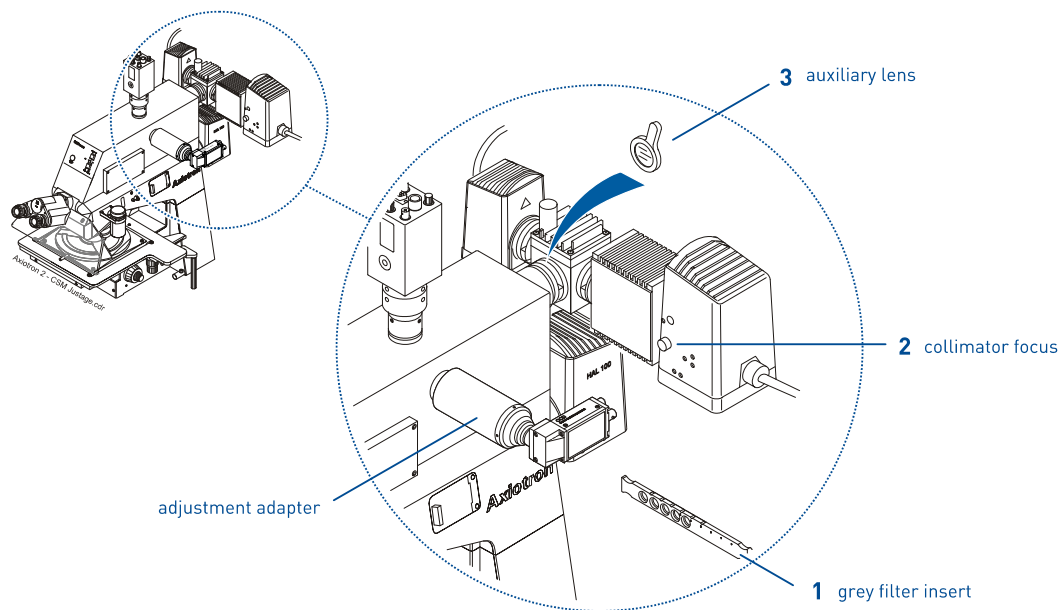


figure 60 Tools required for the fine alignment of the CSM illumination

- Using the adjustment screws at the lamp house, both the electrodes and their reflected image need to be adjusted symmetrically to the (round) objective pupil that is visible on the monitor. The principle of the adjustment is similar to figure 55 and figure 56 on page 85ff. The image will approximately look like figure 61, although the contrast may be insufficient to clearly distinguish the electrodes from the discharge and the reflected image from the electrodes.

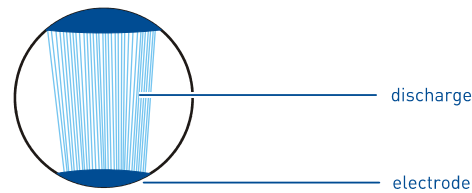


figure 61 Approximate view of the burner electrodes after the fine adjustment

- After having finished the fine adjustment, remove the auxiliary lens and the adjustment adapter (again, exercise caution because of possible contamination of the camera chip).
- Finally, refocus on the wafer surface and adjust the collimator focus (2 in figure 60), until an evenly illuminated image can be observed.

5.10 Backup And Restoring Of Parameters

As mentioned in the sections on optical adjustment of the microscope (see "Microscope Adjustment (Köhler Illumination)" on page 56), certain circumstances may invalidate some or all pre-programmed settings of the microscope. Especially a mains blackout in teach mode will not only change the default settings for the illumination conditions, but also any possible configuration options, such as the support of two light sources, the usage of a confocal scan module (CSM) and others.

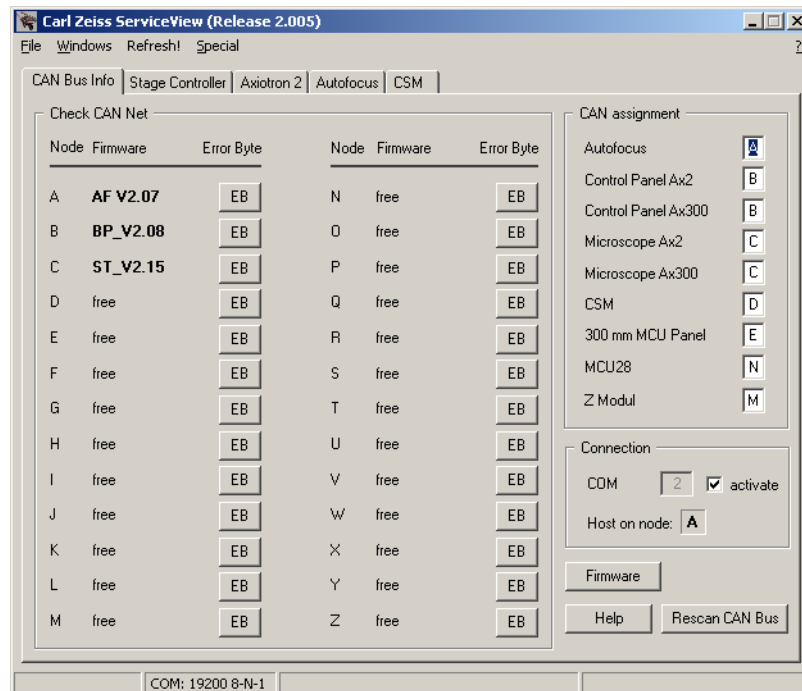


figure 62 Service VIEW after successful scanning of the CAN bus

For all these emergencies, during installation of the microscope a backup of all microscope defaults has been taken, which can easily be restored, if required. Please note, that all customizations that may have been done in the mean time are overwritten in this case. So far, it might be a good idea to take independent backups from time to time and leave the factory defaults stored as a fall-back position of last resort.

The same considerations apply for the parameters stored in the autofocus controller unit. An appropriate procedure is described as well.

- Upon program start, the software should automatically scan for any possible connected devices.
 - Only in case that a message appears, which indicates communication problems, if might be necessary to select a different COM-port to communicate with the CAN bus.
 - The default COM-port for communicating with the microscope components is COM2. If, for any reason, this should have changed, all ports between COM1 and COM9 may be tried. There is no possibility of causing damage to other components.
 - After having corrected the port address, activate the port by checking the respective box and press the [Rescan CAN bus](#) button.
- If the software has found the CAN bus on the COM port that was specified when the software was started, it will be scanned automatically. After a successful scan, behind the nodes [A](#), [B](#) and [C](#) the firmware versions of the autofocus ([A](#)), the Control Panel ([B](#)) and the microscope ([C](#)) can be found. If the system is equipped with a Confocal Scan Module, also node [D](#) will show a version number.

component	node designator	firmware version
autofocus	A	AF_V2.07
microscope control panel	B	BP_V2.08
microscope stand	C	ST_V2.15
confocal scan module	D	CS_V2.05

- In case that the firmware versions reported by the software differ from what is listed above, call the HSEB Service Department in order to check, if a firmware upgrade is required.

5.10.1 Backup Microscope System Parameters

- Follow the procedure in 'Backup And Restoring Of Parameters' on page 91 to start ServiceVIEW.
- Select the tab of the component of which parameters are to be saved and wait for the parameters to be read in completely.
- Verify the correct firmware version as listed above.
- Press the *Parameter Backup* button and specify a file name. Usually the file name offered by the program will be *YYxxxxxx.NOM*.
 - While *YY* defines the component concerned, *xxxxxx* is a place-holder for the system's serial number. Replace the letters *x* by the stand system code of the microscope, e.g. *741785*, which can be found on a label on the back side of the microscope.
 - Please mind, that numbers beginning with 45, like 452809, is the catalogue number of the stand and no serial number. If this figure is used, the backup files would have ambiguous names.

component	default parameter file name
autofocus	AFxxxxxx.PAR
microscope control panel	does not contain a parameter file
microscope stand	STxxxxxx.NOM
confocal scan module	CSxxxxxx.NOM

- After saving the parameters, exit ServiceVIEW.

5.10.2 Restore Microscope System Parameters

- Follow the procedure in 'Backup And Restoring Of Parameters' on page 91 to start ServiceVIEW.
- Press the *Parameter Restore* button and specify the file name of the parameters to be restored. The correct location and file name of backup parameter files can be found in the table above.
- Exit ServiceVIEW and power-cycle the CAN bus system, i.e. switch the entire system off and on. When it has been turned off, wait for a couple of seconds before restarting it. If, for any reason, subsequent power cycles are required, switch the light sources off.

5.11 Known Faults And Their Recovery

- Image out of focus
 - This topic is comprehensively dealt with in 'How To Find Focus' on page 37.
- Pre-programmed light intensities seem to change
 - This problem may have different reasons. One might be an insufficient linearity of the light generator, which means, that the intensity of it changes rapidly for small changes of the potentiometer position. If the intensity has been stored in such an area, it might happen, that upon recalling the microscope presets the light generator delivers an intensity that strongly varies from the programmed value. The best method in this case is to exchange the light generator as a whole. Another solution - more a workaround - is to use the AGC setting of the camera.
- Camera image on monitor shows a tint
 - The white balance of the camera is not set properly.
 - If a HAL100 lamp is used, the colour temperature may change drastically if the intensity of this lamp is adjusted across a bigger range. As the HAL100 is an incandescent lamp, low intensities will appear reddish and high intensities blueish. For that reason, the intensities should all be set to similar values. As this is difficult to see with the automated gain correction in the camera set „on“, it should be turned off before the intensity adjustments are done. After that, AGC may be switched on again.
 - If a light generator is used, the colour temperature does not depend on the light intensity. These light sources use a mechanical comb-shaped shutter to regulate intensity, while the light source itself lights with constant intensity. If for this kind of light source a sudden colour tint is observed, the reason might be one of the semi-permanent optical elements in the beam path. These are the analyser slider, the yellow filter and the position of the slider that defines the amount of light directed to the camera or the eyepieces. A proper white balance is only maintained if the position of these sliders does not change.
 - If an analogue video monitor is used for the display of the camera images, „playing people“ may change the signal scheme from *RGB* to *YUV* in the control menu of the monitor. In this case the image will show a strong tint too.
 - One or more of the coaxial cables are damaged. In this case, the missing signal is also missing in the image.
- Light generator switches off suddenly (LG Xe 180 W remote, „Medexxa“)
 - Check if the air ventilation in and around the light generator is not cut off. Overheating causes a protection mechanism to be activated, which shuts down the light generator.
 - The mains plug may not be fully inserted, which may happen, as it needs to be removed during illuminant exchanges.
 - The light generator may be defect. A replacement may be ordered under the HSEB catalogue number 9010-33896.
- Illumination in the microscope is uneven
 - The frosted glass (diffuser) in the aperture diaphragm assembly of the microscope is not put in the beam path. Open the wicket on the right-hand side of the upper stand part and move it into the beam path by a anti-clockwise rotation. Refer to figure 34 on page 58.
 - The liquid light guide of the light generator might be damaged. Especially an uneven illumination that can be described as large dark areas in the field of view may indicate problems with the light guide. Check, if the light guide has sharp bends. In general, a bending radius smaller than 80 mm may cause damage to

the light guide. Check, if the dark spots move if the light guide is touched. If necessary, order a replacement under the HSEB catalogue number 9010-33895.

- The lamp *LAMP CHG* on the Medexxa light generator blinks red.
 - Instantly exchange the illuminant, as the physical lifetime is about to be exceeded. Replacement illuminants have the HSEB catalogue number 9004-03136.
 - Because of the serious threat of a bulb burst the light generator should not be used anymore until the illuminant has been exchanged.
- Light generator seems to have less intensity than a HAL100 halogen lamp.
 - Probably the short end of the light guide has been inserted into the generator and the long end into the microscope adapter. This is a problem that might occur if the light guide has been previously exchanged.
 - Check if both sides of the light guide are reversed; the longer end of the light guide belongs into the light generator. Push it in until the click stop can be heard. There is no screw or anything else but a click-stop mechanism.
- Other reasons for too little intensity
 - The operation time counter indicates a necessary exchange of the illuminant; and the average intensity has already dropped.
 - Small intensity in darkfield: The aperture diaphragm might not be fully open.
 - The analyser might be in the beam path.
 - The lamp intensity has been taught to a too small value. Keep in mind that the control range in normal operation is only half of the possible range.
 - Check, if the objective/reflector combination that is currently active does blink (this could indicate a defect on the intensity regulation servo in the light generator)
- Burner does not ignite immediately / does not burn homogeneously
 - Check the operation time counter. It might be possible, that the lamp has been switched on and off too often, which has decreased the lifetime of the burner. If it has been switched frequently, it may be necessary to exchange the illuminant prematurely.
- The intensity in CSM mode is not as good as expected
 - The light generator is not designed for use with the CSM mode. Therefore, an remarkable higher light intensity in the CSM module cannot be expected.
 - Furthermore, the limited spectrum of the arc light source will cause the false-colour image to look dim, compared to an image taken with the HAL100.
- The CSM image is not colourful.
 - A HXP light generator is used for CSM illumination. In this case, only yellow and blue colours could be seen.
 - CSM imaging is not done with *Apochromat* objectives. Only *Apochromat* objectives have the optical properties that allow to use the colour spreading properties of the chromatic element that generates the colours.
- On the microscope control panel, the LEDs for the actual objective/reflector combination blink.
 - In the light generator, an error in the intensity regulation servo has occurred.
 - The actual combination of reflector and objective does not have a valid parameter block assigned. This is not a fault caused by the light generator. It is necessary to reset the AF controller using the *Parameter Reset* function and to reload a valid parameter block.

- If both a Medexxa generator and an autofocus are installed, the error message from the control panel is not unique. In this case it is necessary to separate the autofocus to verify, if the problem persists.
- It was observed, that the objective and reflector LEDs on the control panel used to blink on some generators, which indicates a light intensity servo in the generator, that does not follow the pre-programmed intensity values properly. Obviously the tolerance allowed in the microscope parameter file was set too small. It is recommended to change the Medexxa parameters from (1, 20, 50) to (1, 20, 70).
- The light generator does not follow the lamp potentiometer correctly
 - Check if the microscope stand is equipped with firmware level 2.11 or higher. For details, see 'Backup And Restoring Of Parameters' on page 91.
 - Check the control panel is equipped with firmware level 2.05 or higher. This is done in a similar way; the firmware version of the control panel is displayed under the node letter *B*.
- Binocular tube of the microscope sinks down
 - If the binocular tube doesn't hold it's vertical position to which it has been set by the operator, the eyepieces will sink slowly down until they are in their lowest position. To correct this, it is necessary to remove the entire binocular tube and to tighten a 2.5 mm Allen screw that is located behind a hole on the bottom of the tube, just besides the tube lens. As this procedure requires dedicated safety procedures to avoid health hazards by laser radiation and also a remarkable amount of mechanical disassembly, details will be given in a dedicated service training for customer maintenance personnel. If you have not successfully passed this training, call a HSEB service representative.
- Binoculars sink down
 - The same can happen to both binoculars. If they sink down of their own volition, remove the plastic cover in the middle between both eyepieces (it is black and bears a white scale indicating the eye distance) and tighten the two-hole nut. A special tool will be required for that purpose.
- All objective and/or reflector buttons of the control panel blink
 - The microscope was in teach mode when the mains power was switched off. In this case there is not much that can be done except to restore the parameter files. For details see "Restore Microscope System Parameters" on page 93.
 - In any case, do an aftermath of this fault. If the power has been switched off by intention when the microscope was in teach mode, instruct the responsible person that this action does not constitute a proper handling of the instrument.
- Objective or reflector revolver rotate constantly or does not reach target position
- Objective or reflector revolver do not move at all
 - Check, if the objective positions are transmitted correctly to the control electronics. Therefore, use the ServiceVIEW program (see 'Backup And Restoring Of Parameters' on page 91), go to the *Axiotron 2* tab and try to set the revolver position with the buttons in the software. If this works properly, the control panel needs further attention.
 - Check, if the positions reported in the software are correct if the revolver is moved manually. This would indicate a defect micro switch that prevents the revolver from stopping on the correct position.
 - If also the reported position is incorrect and/or the control via ServiceVIEW is not possible, the reason of the fault might be the position feedback sensor, the control electronics board, a slipping tooth belt or a defect revolver motor. Another sign for this kind of fault is, that the indicator lamps on the control panel will go

on when a new position is selected, but the revolver will not move. After trying all positions, all indicators are on.

- Any uncommon (such as a grinding) noise when moving the revolver manually may indicate a mechanical defect. The position sensors at the back of the objective revolver might point out too far and one of the screws that hold the black ring above the objective revolver gets stuck in the hall sensor unit. There should be always enough space for a sheet of paper between the revolver and the sensors.
 - If there are no audible click stops at the expected revolver positions, a broken detent spring is likely, maybe combined with loose parts that get stuck. In the reflector revolver, a defect reflector cube may lose parts which can get stuck in the mechanics.
 - If a slight touch of the objective or reflector revolver causes a big „jump“ of the microscopic image, also on lower magnifications, indicates a defect centre bearing of the revolver.
 - In all these cases, report your observations to a HSEB service representative and await further instructions to identify the problem. In most cases a service visit, if not a factory repair of the microscope will be necessary.
- Reflector revolver do not move at all.
 - According to the systems's parameters, the microscope expects a motorized switching mirror for the use of two light sources. If such a switching mirror was removed before without updating the firmware settings, the microscope still expects the mirror and does not continue to work until said signal is received.
 - It is necessary either to re-connect the mirror or to change the parameters.
 - Eyepiece crosshair is damaged
 - Some eyepieces are equipped with a crosshair made from Nylon wires instead of a glass plate with a reticule. Sometimes people take them out to „clean“ them and inadvertently damage the wires inside. This problem cannot be repaired in the field. The eyepiece needs to be sent back for repair.
 - If this problem should occur with your tool more frequently, ask for a retrofit of the binocular tube with set screws.

5.12 Axiotron 2 Control Panel Messages

The LEDs in the keys of the Axiotron 2 and Autofocus control panel indicate a number of possible operating and failure conditions. The following overview shall give advice in case of unknown messages from the control panel. As the possible signalling of the indicators cannot be more detailed than "lamp on", "lamp off" and "lamp blinking", sometimes, the context of the message, i.e. it is important to know the last action taken.

- The LED on the key *AF On* blinks after changing objective or reflector
 - No target focal plane for the autofocus has been defined. Adjust the focus accordingly and press the *AF On* key for two seconds to teach the new focal plane into the autofocus electronics.
- The LED on the key *AF On* blinks, also after trying to teach the focal plane
 - The level of reflected light from the sample may be too low. If a specimen with little reflectivity is used, such as glass substrates etc., this error may come up. Try to focus on an other, better reflecting part of the sample.
- The LED on the key *AF On* blinks, also after trying to teach the focal plane again and also on a well-reflecting part of the sample.
 - If the problem occurs suddenly after a power-cycle of the system, a firmware parameter problem (no laser defined) could be the reason. Call the field service engineer and explain the problem and the action that has been taken so far.
- Only the reflector indicator is on, the objective indicator is off
 - This is no fault. Probably the *lamp idle* parameter in the Axiotron 2 has been activated. This function acts similar to a screen saver on a computer and turns the microscope illumination off after the microscope has not been used (i.e. no operator action has been detected on the control panel and elsewhere) for a certain time.
 - The lamp will go on, if the objective key is pressed again.
- LEDs for the actual combination of reflector and objective blink.
 - If the high power xenon light generator by Medexxa is used, an error in the intensity regulation servo may have occurred. Call the field service to rectify the problem, if it should persist over a certain time. The error condition is not dangerous; as long as the light intensity still can be smoothly regulated, it may be the case that only a software limit in the light source has been set too tight.
 - The actual combination of reflector and objective does not have a valid autofocus firmware parameter block assigned. It is necessary to reset the AF controller by usage of the *Parameter Reset Function* and to re-load a valid parameter block. As this is not a setting that can be done by an operator, call the field service to rectify this failure.
- The green LED at the back side of the microscope control panel blinks
 - This is no fault. A blinking green LED means, that the CAN Bus, that interconnects the control panel, the microscope, the CSM module, the stage controller and the autofocus controller, is alive and working.
- The red LED at the back side of the microscope control panel is on
 - A failure during communication between the control panel and the microscope has occurred. If the control panel works fine, the error can be ignored, as it is stored for an indefinite time after occurrence.
- The LEDs on the objective or reflector keys go on when the keys are pressed. The microscope does not move any objective or reflectors, however.

- This may have a variety of possible reasons. Among them, the microscope may have lost its parameter set or the control panel or the autofocus may be damaged. Call the field service to rectify the failure.
- After having changed the objective, the actual objective key blinks
 - The Axiotron 2 microscope supports the use of immersion objectives. For use with these objectives, the stage will move down in order to allow the user to apply immersion fluid to the front lens of the objective. While the microscope waits for the operator, the objective key will blink. After the operator has pressed the objective key again, the stage will move back up to its working position.
 - If the microscope should show the behaviour described, but without immersion objectives being used, maybe a firmware parameter has been set wrong. Call a field service engineer to rectify the problem.
- Only *AUX* blinks, the other LEDs are off
 - The control panel needs a firmware upgrade to version 2.05 or higher. As the stand parameters probably will be lost as well (after the next power cycle all objective buttons will blink), it will be necessary to restore the microscope parameters. Call a field service engineer to rectify the problem.

5.13 Spare Parts

Below a list of most required spares and consumables can be found. „Trivial“ parts, such as fuses are not listed. Accessories, like different types of eyepieces, camera adapters etc. can be found in the respective chapters of this manual.

part number	description
9444-80100	eyepiece eyecup
9467-82800	heat protection filter
9444-83002	auxiliary microscope for Köhler illumination
9010-88996	adjustment kit for CSM VIS-UV
9417-00900	face protection shield to exchange arc lamp illuminants
9380-07994	halogen bulb 12V/100 W
9004-51413	illuminant for HgXe100 lamp
9380-30150	illuminant for HBO103 lamp
9380-05370	illuminant for XBO75 lamp
9004-03136	illuminant for Medexxa light generator
7600-00021	illuminant for HXP light generator

5.14 Computer Control

The Axiotron 2 can be remote controlled by a RS232 interface. As the control of the system is not limited to the microscope itself, but can be extended to all components of the microscope family (control panel, CSM head, Laser autofocus, MCU28 motor control) only the most important commands for the microscope head are listed here.

For the other commands, a comprehensive list is available from HSEB in Dresden.

5.14.1 Hardware and Protocol

To communicate with the stand, a fully wired RS232 zero modem cable is required. Physically, it features two „female“ connectors and connects between the RxD/TxD as well as between the RTS/CTS signals.

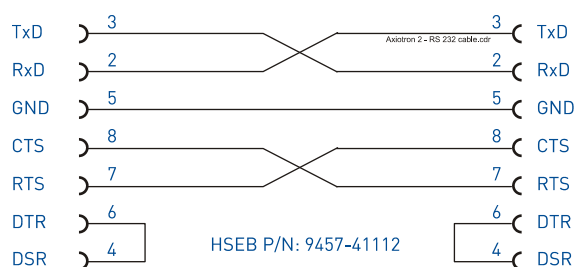


figure 63 The RS232 connection cable

The communication parameters are 9.600 bps, 8 data bits, 1 stop bit, no parity.

5.14.2 Commands

A command is maximum 8 ASCII characters long. In figure 64 the command syntax can be found.

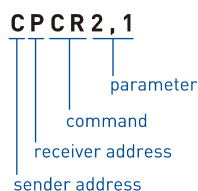


figure 64 General pattern for a RS232 command

Each CAN component features an address, that is represented by a capital letter:

CAN node	description
A	laser autofocus
B	control panel
C	stand
D	CSM module

CAN node	description
N	MCU 28 stage controller
P	Computer (virtual CAN component)
T	Transmitted light controller

The CAN command may consist of capital letters only, if they constitute a command (e.g. *CPCR1,x* for setting the reflector revolver to position *x*) or they may contain small letters, in this case the current position is queried (e.g. *CPCr2* reads out the current position).

Below a list of the most frequently used commands can be found.

CAN node	description
ES1	enable control panel keys and potentiometers
ES0	disable control panel keys and potentiometers
Tv	read current firmware version
Eb	read error byte (that makes the red LED at the back lighting)
CR1, <i>n</i>	set objective revolver to position <i>n</i> (1...5)
Cr1	read objective revolver position
CR2, <i>n</i>	set reflector revolver to position <i>n</i> (1...4)
Cr2	read reflector revolver position
CV1, <i>nnn</i>	set lamp to value <i>n</i> (0...255)
CV5, <i>nnn</i>	set aperture diameter to value <i>n</i> (0...255)
CV6, <i>nnn</i>	set analyser to value <i>n</i> (0...255)
CV7, <i>nnn</i>	allow manual adjustment
Cv <i>n</i>	read value for lamp (<i>n</i> =1), aperture (<i>n</i> =6) or analyser (<i>n</i> =7)

There a dedicated handbook available, that contains a comprehensive description of all available commands.

5.15 Notes On Optics Cleaning

Cleanliness of the optical components is a fundamental requirement for the optical performance and sensitivity of the instrument. The usage of the Axiotron 2 normally does not involve the exposure, removal and re-insertion of optical components.

To minimize the need for optics cleaning, always cover unused optical parts, for example by storing in their appropriate containers or at least by a sheet of clean paper or a cleanroom cloth. If exposed storage cannot be avoided, try to store such components with the optical surfaces down or vertical.

In this handbook, the focus is put on the possible dangers for optical parts if they are treated incorrectly. Operators generally should avoid to clean optics by themselves. If, for any circumstances, optics cleaning cannot be avoided or delegated, methods for dry cleaning are described. Cleaning of optical components using fluids of all kind should be carried out by trained service personnel only. A manual on the more advanced procedures is also available.

RISK OF DAMAGE TO OPTICAL COMPONENTS

Air blown from the mouth *always* contains droplets of saliva. Never try to blow dust particles away from optical components with your mouth.

Moisture droplets may also emerge from spray cans with pressurized air and contaminate optical components. The same effect may occur with oil from pressurized air line supplies in laboratories. Pressurized air from spray can or air line must never be applied to optical components.

Blow bulbs, which originally have been manufactured for other purposes than cleaning of optics, such as medical bulbs, may have been treated inside with talcum to prevent them from sticking when squeezed. This talcum may be blown out when such a bulb is used to clean optics and can cause serious consequential damage to optical surfaces. Never use other blow bulbs as those made for optics cleaning.

Special optics cleaning fluids, that are to be applied, to be dried and to be pulled off as a solid (rubber-like) film with all adhering particles, are not recommended, as in case of tearing the residues might not be removable without serious consequential damage to the optics surface.

Fingerprints, which are left on coated surfaces of optical components, such as lenses or filters, may destroy the anti-reflection coatings and permanently impair their optical performance. For that reason it is strongly recommended to clean touched optics immediately.



Blow dust off using a rubber blow bulb. The blowing direction is always towards the outside, or from top to bottom. Avoid using a blow bulb in environments, where additional dust may be stirred up and deposit on optical surfaces. To verify the success of the cleaning process, watch a light source with the optical surface in question acting as a mirror before a dark background. Tiny spots become easily visible in that way.

Carefully aspirate onto the surface and watch the condensation disappear. Do not try to blow a sharp airstream across the surface, as this will contaminate the surface again. The condensed water should disappear evenly within a moment. Remaining dirt, grease in particular, will cause the condensation to remain much longer and indicates need for additional cleaning.

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